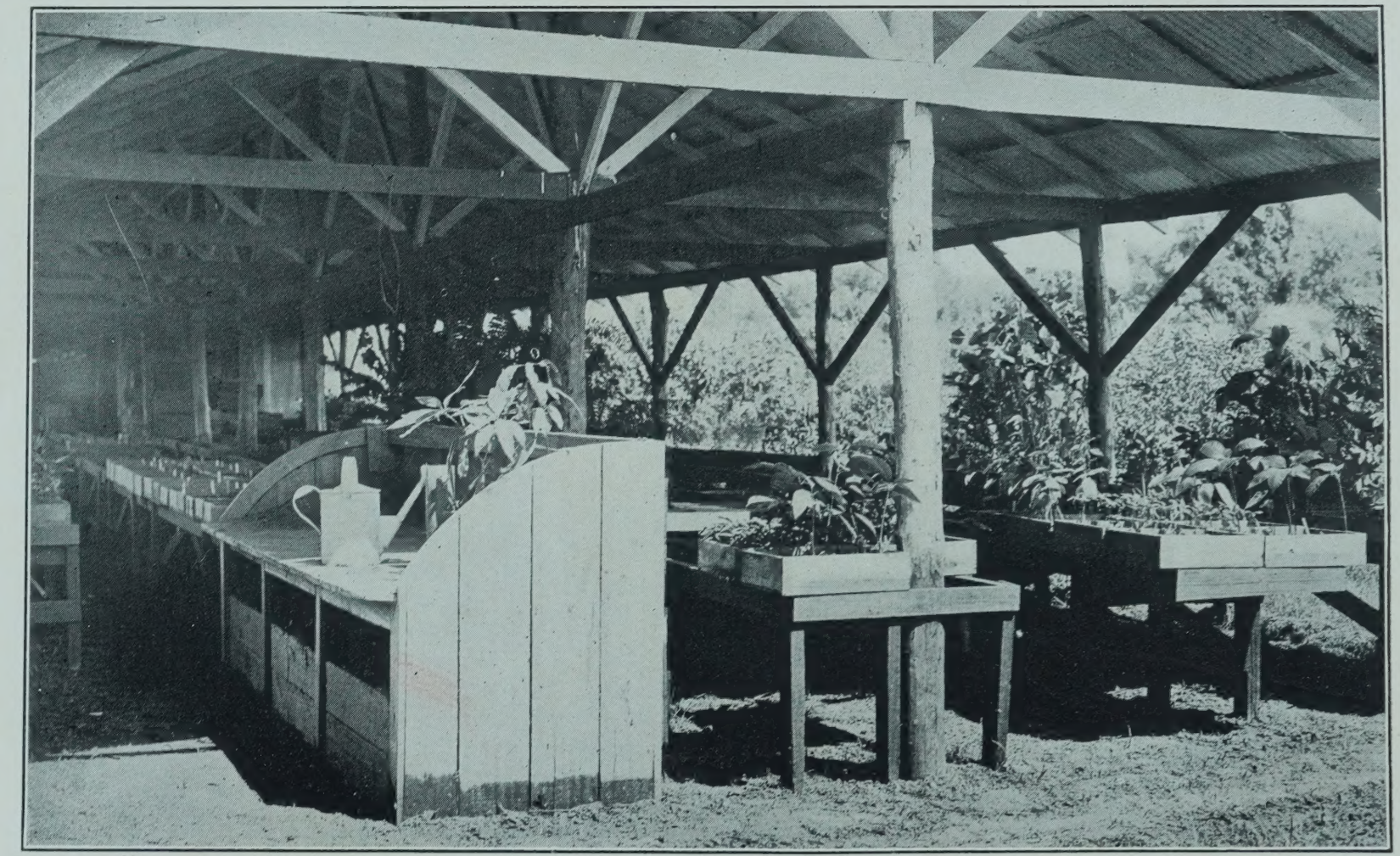
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Plant-propagation shed, Lamao experiment station.

THE PHILIPPINE

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EDITORIAL.

THE SUGAR INDUSTRY.

It is supposed that the sugar cane (*Saccharum officinarum*) was originally found in India, probably in the region of the Ganges. There is no sugar cane known anywhere to-day in the wild state although there are several species of mammoth grasses closely akin to this plant.

As various portions of the earth's surface were explored and finally settled the sugar industry was extended until to-day one finds it flourishing in practically all tropical countries and many subtropical countries as well. Perhaps the last semi-tropical region to attempt this industry in a commercial way was the State of Arizona, U. S. A., where the desert wastes were turned into flourishing beet and cane fields by the aid of irrigation from the Government storage dam.

During the reign of Napoleon in France trade in the sugars from British and other foreign possessions was destroyed by the war with England but this decline in the cane-sugar trade served only as an impetus to the new beet-sugar industry then being started. In the meantime there was such a dearth of sugar and such a fabulous rise in prices, that attempts were made to secure sugar from various plants and fruits growing in France, such as beets, sorghum, maize, grapes, apples, pears, figs, etc.

At that time the manufacture of a kind of sugar from grapes became quite important so that during the period from 1811 to 1813 considerable quantities of this class of sugar were made. Simultaneously with this new venture the beet root was gaining in importance year by year, especially in France, and to a certain extent as well in other European countries, until after extensive experiments in plant breeding it was learned that the sucrose value of the root could be very much improved. From this work varieties of beets used to-day have evolved which often contain as high as 20 to 25 per cent sucrose. Another obstacle in the way was the bad taste and odor of the low-grade sugars from the beets and the difficulty of making a high-grade sugar. To-day the heavy liming and the carbona-

tion process give a sugar equal in all respects to the best grade of granulated cane sugar, and one finds a great deal of beet sugar either mixed with cane sugar or marketed alone under the name of cane sugar.

At the present time the beet-sugar industry has become so important that more than eight million tons, or about one-half of all the sugar produced, comes from this source.

There is a greater consumption of sugar each year which necessitates greater production either through larger areas, heavier yields, or its manufacture from other saccharifèrous plants. The maximum in both area and yield have by no means been reached, while in recent years a large number of saccharifèrous plants have attracted the attention of various investigators throughout the sugar world, and this will in all probability lead to a new source of supply. The most promising of these plants is the sugar palm (*Arenga saccharifera*). Extensive work was conducted on this palm by this Bureau and reported in the May, 1914, number of the PHILIPPINE AGRICULTURAL REVIEW. During the above-mentioned year an entirely new method of juice clarification was elaborated which is applicable to the juices of various other palms as well as to that of the sugar cane.

In Bengal the wild date palm (*Phoenix silvestris*) has produced a low grade of molasses sugar for consumption by the natives for a great number of years. The main obstacle encountered in making a good grade of sugar from this palm has been caused by the difficulty of clarification and the susceptibility of the juice to fermentation. It is thought that the above-mentioned process may bring this palm into greater prominence in the sugar world.

There are also the Palmera (*Borassus flabelliformis*) of Southern India, and the Nipa (*Nipa fructicans*) of the Philippines. Either of these could undoubtedly be made profitable sugar producers. The latter is used commercially only as a source of alcohol.

There is practically no limit to the number of saccharifèrous plants one might name in the Tropics and subtropics, but many of these do not contain a sufficient percentage of sucrose, or else they contain such a high percentage of impurities that the low yield of sugar and the high cost of manufacture make their use unprofitable.

CITRUS FRUITS IN THE PHILIPPINES.[1]

By P. J. WESTER, *Horticulturist in Charge of Lamao Experiment Sation.*

PRELIMINARY REMARKS.

De Candolle, in his "Origin of Cultivated Plants," discusses 5 species belonging to the genus *Citrus:* The pomelo, *C. decumana* L.; the citron, lemon, and lime, here considered as distinct species, which he includes under the one species, *C. medica* L.; the sweet orange, *C. aurantium* L., which he separates from the sour orange and which is also by him considered as a distinct species, *C. vulgaris* Risso; and finally the mandarin, *C. nobilis* Lour. Of these, the pomelo, orange, mandarin, lemon, lime, and citron are important pomologically, the sour orange being grown principally as stock for the other species.

The pomelo is by the same author considered to be indigenous to the Pacific Islands east of Java, the citron and affiliated species to have originated in India, and the sour orange east of India, and all to have been in cultivation for over two thousand years. The antiquity of the orange and mandarin is less, both species being from China and Cochin China.

All these species have been introduced into the Philippine Archipelago, and are well distributed excepting the sour orange, which is rarely seen. The discussion of all species refers to them as found in the Philippines except when otherwise stated.

No very distinct types are found among the oranges or mandarins; the variation in the pomelo is considerable, although,

[1] Bureau of Agriculture Bulletin No. 27, Citriculture in the Philippines, 1913, contains illustrations of several unnamed citrus fruits described in this paper. Those readers who possess the above-mentioned bulletin may be interested to know that in accordance with the classification herein these fruits should be named as follows:

Bull. No. 27, Plate IV, Mandarin Lime=*C. webberii;* VIII, Lime (Mindanao type)=*C. excelsa* var. *davaoensis;* VIII, Lime, "Limon Real"=*C. excelsa;* X, Cabuyao=*C. histrix;* XI, Cabuyao=*C. histrix* var. *torosa;* XII, Biasong=*C. micrantha;* XII, Type from Bohol=*C. histrix* var. *torosa;* XII, Type from Bohol=*C. histrix* var. *boholensis;* XIV, Colo=*C. macrophylla;* XIV, Samuyao=*C. micrantha* var. *microcarpa;* XV, Talamisan=*C. longispina;* XV, Tizon=*C. nobilis* var. *papillaris;* XV, *Tihi-tihi*=*C. medica* var. *odorata;* XVI*a*=*C. webberii* var. *montana;* XVI*b*=*C. southwickii.*

so far as the writer has noted, scarcely enough to warrant the distinction of separate varieties. Both the white and red-fleshed types occur with many gradations, but no studies have been made to note which other correlative characters, if any, are identified with these different forms. The very primitive pomelos (Pl. II, *c*) that are not infrequently seen in cultivation might indicate that this species is indigenous to the Philippines, though so far as the writer knows the tree has never been seen in the virgin forest. Closer observations have been made on the general type represented by the citron, including the lemon and lime, and several distinct forms have been recognized.

The calamondin, *C. mitis* Blanco, is well known to be indigenous, as well as the cabuyao and related plants that have been referred to *C. histrix* DC. In the first-named species there seem to be no very marked variations.

C. histrix was described by De Candolle, flowers and fruits excepted, from a plant growing in Montpellier, being recognized principally by its long broad-winged petioles and free stamens. The writer has not had the opportunity to see the original description of *C. histrix* or examine the type specimen, but Swingle refers to it in Jour. of Agri. Research, Vol. I, No. 1, page 10, 1913, as having broadly winged petioles, often larger than the blades, the wings being more gradually narrowed toward the base and usually more abruptly truncate at the tip than *C. ichangensis* Swingle, making then somewhat triangular in outline.

Within these broad limitations a number of otherwise remarkably distinct forms may be recognized some of which were illustrated in a previous publication, Bureau of Agriculture Bulletin No. 27, Citriculture in the Philippines, 1913, and referred to *C. histrix* with the statement that "some of these forms unquestionably will be recognized as subspecies on closer study, or possibly as separate species." Since then several plants of this type in the citrus collection assembled at Lamao by the Bureau of Agriculture have bloomed and fruited, affording an opportunity for fuller observations, and these have been further complemented during a trip to Bohol and Cebu in May, 1914, and by the fruits forwarded by Mr. E. F. Southwick.

However, assuming that *C. histrix* (or some of its subspecies) is the *C. histrix* of De Candolle, there still remain, on one hand the limao, and on the other the biasong, balincolong, samuyao, samuyao-sa-amoo, as widely different from each other and the cabuyao and its subspecies as for instance the orange, and pomelo, or the mandarin and the calamondin. A very in-

teresting characteristic has been discovered in several of the citrus fruits that have free stamens in the form of a more or less distinct nucleus in the juice cells; this, so far as the writer knows, has not been previously recorded in a citrus fruit. The fact that the presence of these nuclei is not here referred to in some species with free stamens does not necessarily mean that they are absent, considering that fruits of these particular species have not been examined since the first nuclear cells were discovered. The writer is inclined to believe that these nuclei are correlative to those species having free stamens.

To the student in the citrus-growing sections of the United States the characterization of the citron, lemon and lime as given herein is no doubt satisfactory, but in the Philippines various forms called "limon" will appear that do not agree with this and it would then be necessary either to make the descriptions more general so as to cover the additional forms or to classify these as species or subspecies. If the barely margined petioles, comparatively small leaves, the green, tender growth and the white corolla are insisted upon for the lime, for instance, it is difficult to know where to place the purple-growthed, thorny, wide-winged, purplish-petaled, subglobose limes with wide-winged leaves of the Philippines. They cannot well be placed with the lemons, and still less with the citron, though they of course show strong relationship to each. The citron group of the genus perhaps more than any other shows the need of further study and systematization of the entire genus.

Attention should be called to the presence in the Philippines of the extremely primitive types of the citron and the lemons; for instance, the fruit illustrated in Bulletin No. 27, Plate XVI (*c*), and colo-colo, as well as the lombog, referred to *C. pseudolimonum* in this paper.

Of all the plants here discussed, *C. micrantha* var. *microcarpa* is botanically furthest removed from the cultivated citrus fruits.

Each considered as a separate species and constituting perhaps the most complete description of these species published in English, Mr. H. H. Hume's characterization of the orange, sour orange, mandarin, pomelo, citron, lemon, and lime in his "Citrus Fruits and Their Culture," is here reproduced without alteration. Some writers have grouped several of these as subspecies under one great comprehensive species, but, as Mr. Hume aptly says: "What advantage is there in throwing the sour orange, sweet orange, pomelo, kumquat, and a few other distinctly different trees into one conglomerate species * * * and then placing each of the aforementioned plants under this

species as subspecies and varieties. Such a procedure is more likely to result in further confusion than order."

The species of the genus *Citrus* that have come under the observation of the writer, with two exceptions, seem naturally to divide themselves into two groups,—(1) those with more or less united filaments and hypogeal cotyledons, and (2) those with free filaments, and (in all instances where there has been an opportunity for observations) with supra-terraneous, distinct cotyledons (fig. 1). In so far as these characteristics have been observed in the Philippine citrus fruits, long and broad-winged petioles are a third correlative feature distinguishing group No. 2; *C. ichangensis* recently described by Swingle from China also possesses this last feature, but has connate filaments. The alsem and alemow seem to be intermediate between these forms, the alsem being most closely related to those in the first division, the filaments being connate, while the cotyledons in some lots that have been propagated appeared above ground. The alemow is most closely related to group No. 2, the filaments being nearly always free. The general character of the talamisan together with the presence of hypogeal cotyledons tends to the belief that this species has more or less united filaments and thus would belong to the first group.

All descriptions have been made from living plant material either during tours of collection by the writer, or from plants grown at the Lamao experiment station from material sent to the Bureau of Agriculture from time to time since April, 1911. Also, all the material has been collected from plants growing in the yard of some Filipino and so may lay claim to having been domesticated. While this statement may not be altogether reliable it is interesting to note that in Bohol the Filipinos stated that the following trees grew wild in the forest: Amongpong, amontay, balincolong, biasong, canci, colo-colo, limoncito, limao, lombog, and samuyao.

While it is believed that the species described in this paper include most of the more distinctive Philippine citrus fruits, and several hitherto unknown even to the botanist, they do not by any means exhaust the Philippine forms of this genus. Several other forms have been noted, and constitute a part of the citrus collection at Lamao but are not here referred to, for the reason that the material on hand is too incomplete to warrant their description at this time.

Acknowledgements.—The writer is greatly indebted to Mr. E. F. Southwick, superintendent of the demonstration station at Cebu, for his untiring zeal in repeatedly forwarding sets

of citrus fruits and budwood from Bohol and Cebu, and for his most valuable assistance during a collection trip made by him and the writer to Cebu and Bohol in May, 1914, without which it would not have been possible to obtain much of the data and material collected. All the species and varieties credited to Bohol were first called to the attention of the Bureau by Mr. Southwick. Mr. G. W. Weathersbee, formerly agricultural inspector of this Bureau, first called attention to the alemow and has also assisted in the collection of citrus material in Cebu. Mr. A. M. Burton, formerly superintendent of the Trinidad garden, Benguet, has forwarded fruits and budwood of the cabugao and other fruits. Mr. D. B. Mackie, entomologist of the Bureau, first called attention to a variety of alsem in Bontoc of superior quality. M. G. B. Mead sent the first specimens of Panuban.

DESCRIPTIONS AND COMMENTS.

Citrus aurantium L. ORANGE.

A tree 7.5 to 12 meters in height, with a compact, conical head; bark grayish brown; thorns generally present, 12 to 50 millimeters long, sharp, stout; leaves oval or ovate oblong, 7.5 to 10 centimeters long, smooth, shining, somewhat lighter below than above, margins entire, or very slightly serrate; petiole 12 to 25 millimeters long, slightly winged (occasionally with quite a broad wing); flowers axillary in clusters of one to six, white, sweet scented, smaller than those of *C. vulgaris;* calyx cupped; sepals four to five, awl-shaped, thick, greenish, persistent; petals usually five, oblong, 25 to 31 millimeters long, thick, fleshy, recurved; stamens twenty to twenty-five, hypogenous, filaments flattened, united in groups, shorter than the petals; pistil distinctly divided into stigma, style and ovary; stigma knob-like; style long and slender; ovary rounded, 10 to 14 loculed; fruit globose to oblate, light orange to reddish; rind smooth; pulp juicy, subacid; juice sacs spindle shaped, sometimes larger than those of *C. vulgaris;* seeds few or many, oblong ovoid, planoconvex, generally broad, wedged or pointed at the micropylar end, marked with oblique ridges surrounding one or two plain areas. Native to China or Cochin China.

While the orange is nowhere planted in orchards it is fairly well distributed. Judging from the prevalence of the citrus fruits in the markets in the various parts of the Archipelago it ranks fifth in production, as compared with the mandarin, pomelo, lime, and calamondin, the only citrus fruits beside the orange that may claim to be of any economic importance even from a Philippine point of view. Excepting a few budded trees of recent importation or distribution by the Bureau of Agriculture all trees are seedlings and nearly always the fruit is poor in quality.

So far as noted, there are no variations worthy of notice.

Citrus vulgaris Risso. SOUR ORANGE.

(Seville orange, Bigarade orange.)

A small tree, 6 to 9 meters in height, with a dense compact head; young shoots light green, thorny; thorns alternate, small, sharp and pointed, on older wood larger, strong, stiff; leaves unifoliate, evergreen, alternate, ovate, pointed, strongly and peculiarly scented; petiole 12 to 18 millimeters long, broadly winged; flowers in small, axillary cymes, white, strongly sweet scented, somewhat larger than those of *C. aurantium;* calyx cupped, segments 4 to 5, blunt; petals linear oblong, conspicuously dotted with oil cells; stamens 20 to 24; filaments united in groups; pistil club shaped, smooth; ovary 6 to 14 loculed; fruit orange colored or frequently reddish when well matured, inclined to be rough; rind strongly aromatic, bitter; pulp acid; juice sacs spindle shaped, rather small; seeds flattened and wedged toward the micropylar end, marked with ridged lines. Native to southeastern Asia, probably in Cochin China. Hardier than the sweet orange.

Samples of what seems to be the sour orange have been received from Davao, Mindanao.

Citrus nobilis Lour. MANDARIN.

A small tree 3.6 to 6 meters in height, with a dense head of upright or willowy, drooping branches; bark dark brownish or streaked with gray; branchlets light green or dark in color, small, slender, round or angled, thornless, or provided with small sharp spines; leaves small, lanceolate to oval, slightly crenate; petioles short, wingless, or with very small wings; flowers terminating the branchlets or axillary, sometimes clustered, 18 to 25 millimeters across, sweet scented; calyx small, shallow, cupped, the petals small; petals white, fleshy, recurved; stamens 18 to 23 in number, shorter than the petals; pistil small, resembling that of *C. aurantium;* ovary 9 to 15 loculed; fruit distinctly oblate, orange to reddish in color; pulp sweet or subacid; juice sacs broad and blunt; seeds top shaped, beaked, cotyledons pistache green; embryos one or more; sections separating readily from each other and from the rind; rind thin, oil cell somewhat balloon shaped or oval. Native to Cochin China. Generally admitted to be somewhat hardier than the sweet orange.

The mandarin is the only species in the genus *Citrus* that has been at all systematically planted and cared for, even though this mostly consists in the planting the trees, now and then the clearing away of the weeds with cutlasses and the harvesting of the fruit. Nevertheless the quality of the fruit is uniform and very good.

The mandarin district of the Philippines is confined to a small area principally around Santo Tomás and Tanauan, in the Province of Batangas, and, excepting imported fruit, all mandarins marketed in the Philippines are grown in the above-mentioned region. Scattered trees are found in most parts of the Archipelago. Aside from the tizon, which is described later, and

which it is believed may be referred to this species, there are no well-defined varieties of the mandarin.

Citrus nobilis var. *papillaris* Blanco. TIZON.

(Plate II, *b*)

A spreading, small tree, attaining a height of 6 meters or more, in habit similar to the pomelo; spines small, or wanting; leaves 10 to 14 centimeters long, 5 to 6 centimeters broad, ovate to elliptical oblong, crenate, dark-green and shining above, crinkly, base broadly acute, apex narrowly acute to almost acuminate and caudate; petioles 17 to 20 millimeters long with narrow wing margin; flowers not seen; fruit large from 6 to 10 centimeters in diameter, 170 to 580 grams in weight, somewhat compressed at basal half, usually ending in a more or less conspicuous nipple which, however, is sometimes wanting; apex flattened, or even depressed; surface smooth, pale greenish turning to orange yellow; skin medium thin; locules 10 to 11, separable from each other and the skin like the mandarin; pulp yellowish, subacid, very juicy, and of good flavor with marked "quinine" taste; juice cells large; seeds very few, rarely more than 7.

The tizon is extremely rare and only a few trees are found in cultivation, confined to the citrus district of Batangas, Luzon. The trees are said to be quite prolific, and the fruit matures from September to December. This fruit, on account of its scarcity, is of no commercial importance. However, it would be an acceptable dessert or breakfast fruit, being a little more acid than the orange. It is said to be an introduction from Spain. The tizon is without doubt the *C. papillaris* described by Blanco in "Flora Filipinas."

The tizon is believed to be a natural hybrid between the mandarin and the pomelo. It has inherited the loose-skinned character, large juice cells, and partial absence of spines, and leaf character of the first-named species to which it is (without the writer having had the opportunity to examine the flowers) unquestionably more closely related than to any other species in the genus. The tizon is represented in the citrus collection at the Lamao experiment station under Bureau of Agriculture No. 744 and 745.

Citrus decumana L. POMELO.

A tree 6 to 12 meters in height, with a rounded or conical head, and a trunk upwards of 45 centimeters in diameter; bark smooth, grayish brown; young leaves and shoots sparsely pubescent, light green; leaves ovate, blunt, pointed or rounded, emarginate, smooth, dark, glossy green, leathery, margin crenate; petioles articulated, broadly winged; flowers produced singly or in cymose clusters of 2 to 20, sweet scented; calyx cupped, large; sepals 4 to 5, pointed; corolla white, 37 to 43 millimeters across; petals 4 to 5, slightly reflexed, fleshy, oblong; stamens 20 to 25;

anthers large, abundantly supplied with pollen, proterandrous; pistil stout; stigma when ripe covered with a sticky, milky fluid; ovary 11 to 14 loculed; fruit large, oblate, globose or pyriform, light lemon or orange colored; flesh grayish or pink; juice sacs large, spindle shaped; flavor a mingling of acid, bitterness and sweetness or subacid; seeds large, light colored, wedge shaped or irregular, with prominent ridges surrounding broad, flat areas. Native to the Polynesian and Malayan Archipelagos.

The pomelo is the most widely distributed species in the genus, but here as in the orange the quality of practically all the fruit is wretchedly poor, dry and insipid with a very thick skin. With the exception of the panuban, described below, there are no variations worthy of notice in this genus.

Citrus decumana L. POMELO, var. PANUBAN.

A spiny tree, 3 to 4 meters tall of robust growth; young growth pubescent; leaves 12 to 17 centimeters long, 4.7 to 8 centimeters wide, oblong ovate, crenate, coriaceous; base rounded; petiole 15 to 23 millimeters long, wing margins narrow, at most 18 millimeters broad, and cuneiform; flowers not seen; fruit 5.7 centimeters long, 7 centimeters in transverse diameter, oblate, with shallow apical cavity; surface smooth, lemon yellow; skin very thin; pulp contained in 11 to 12 locules, yellowish, fairly juicy, subacid, acidity and sweetness well blended, aromatic and well flavored; seeds large, polyembryonic.

The panuban is said to bloom about New Year and the fruit ripens in September to November; the trees are reported to be very prolific. The panuban has been reported only from Lias, Bontoc, where half a dozen trees are said to grow. Possibly the panuban may be an accidental hybrid between the pomelo and the orange or mandarin; if it is simply a mutation it is certainly one of the most striking in this species. However this may be, the pomelo character is strongly dominant in both the foliage and the fruit. Very well flavored, the fruit is too dry to be acceptable to a discriminating public, but it is not improbable that under cultivation the juiciness would increase. In such a case the panuban might become a fruit of commercial importance.

B. A. No. 5160 (Lias, Bontoc).

Citrus mitis Blanco. CALAMONDIN.

A small, somewhat spiny tree, 4 to 6 meters tall; young growth greenish; leaves elliptic oblong, 4 to 9 centimeters long and about 4 centimeters wide, crenulate; base acute; apex usually emarginate; petiole scarcely winged, 10 to 15 millimeters long; flowers axillary, solitary, rarely in pairs, 21 millimeters in diameter, fragrant; petals white, reflexed; stamens 18 to 20, unequal; filaments united into groups; ovary globose, 6 to 8 loculed; style slender, distinct; stigma knoblike; fruit globose, orange

yellow, 2 to 4 centimeters in diameter; skin smooth, thin, brittle, separable from the flesh; pulp orange colored, juicy, acid, with distinct aroma; juice cells rather large, short, and blunt; seeds comparatively large, smooth, plump, sometimes beaked; polyembryonic.

The calamondin is widely distributed in the Philippines and occurs wild as well as cultivated. The plant makes an attractive, ornamental, small tree and the fruit may be made into marmalade or utilized in making ade. There are no particularly distinct forms of this species. The trees are almost invariably very prolific and almost everbearing. In Bohol the species is known as "limoncito."

B. A. No. 2332 (Tanauan, Batangas).

Citrus webberii. ALSEM.

A shrubby tree with small, sharp spines; leaves averaging 95 millimeters in length, and 32 millimeters in width, oblong-ovate, crenulate, dark green and shining above; base broadly acute; apex emarginate, petiole 27 millimeters long; wings rarely exceeding 12 millimeters in width; flowers terminal, rarely axillary, solitary, 20 millimeters in diameter, sweet scented; calyx small; petals white, reflexed; stamens 19 to 21, about equal; filaments united into groups of several; ovary small, obovoid, 7 to 11 loculed; style distinct, slender; stigma small, club shaped; fruit sometimes attaining a weight of 165 grams, form oblate, 58 millimeters long to 65 millimeters long to 66 across, to roundish oblate, sometimes compressed and wrinkled toward base ending in a pronounced nipple; apex a shallow depression, or mammilate with the circular depression more or less pronounced; surface smooth to fairly smooth; color greenish yellow to lemon yellow, lenticels few, depressed; skin thin, the "kid-glove" character more or less pronounced; flesh whitish to grayish, very juicy, aromatic; juice cells variable, from short and blunt to medium slender and tapering to one end; seeds ovate, flattened, smooth, sometimes beaked.

Plants of the alsem have never been seen by the writer in the provinces, the description of the plant having been made from budded plants growing at Lamao, propagated from material collected in Bulacan. The trees have a long flowering season, as fruits are offered in Manila throughout the summer to late in autumn. The variation in the fruit is very great, some being of little value, while others are extremely thin skinned, well flavored, juicy, aromatic, with less rag than perhaps any citrus fruit that has been examined by the writer. The floral characters correspond closely to those of the mandarin, which the fruit in some forms also resembles in appearance and in its loose-skinned character. Flavor and aroma place the alsem in close relationship with the cabuyao, *C. histrix*, and it is a curious fact that the Tagalogs always call it "cabuyao." In common with the cabuyao it is frequently infested with the

rindborer, *Prays citri*, while the mandarin is practically immune to this pest.

An analysis made by the Bureau of Science in November, 1912, of alsem fruits purchased by the writer in Manila gave the following results:

Weight of—	Grams.
Fruit	56.5
Peel	15
Seed	1.5
Pulp (rag)	13.5
Juice	26.5

Analysis of juice.

	Per cent.
Acidity (citric)	5.41
Sucrose	None.
Sugar	2.41
Protein	.33
Ash	.39

Analysis of pulp.

	Per cent.
Acidity (citric)	2.73
Protein	1.03
Ash	.58

The alsem was considered a variety of the mandarin in Bulletin No. 27, Plate IV, but a closer study of the plant and fruit shows that it differs so greatly from all other Philippine species of the genus as to be entitled to specific rank, and it has been named in honor of Dr. H. J. Webber, director of the citrus experiment station, Riverside, California, the association with whom, in connection with his citrus and pineapple breeding work, more than any other cause influenced the writer to take up the improvement of tropical economic plants.

The Bontoc local name "alsem" is here proposed as the vernacular name for *C. webberii*. In previous publications by the writer it was called the "mandarin lime," which is hardly suitable, however, since while it has certain resemblances to the mandarin yet is distinct from it, and again, its only resemblance to the lime lies in its acidity and ade-making qualities; moreover the name "mandarin lime" is too long for popular use.

B. A. No. 853 (Bulacan), 2275 (Manila), 4292 (Bontoc).

Citrus webberii var. *montana*. CABUGAO.

A shrubby tree with slender branches and small, weak spines, sometimes absent; young growth green; leaves 8.5 to 14 centimeters long, 3 to 3.5 centimeters broad, ovate to ovate oblong, crenate, dark green above, shining; base broadly acute to rounded; apex blunt pointed, usually retuse;

petiole 24 to 38 millimeters long, with narrow wing margin, in large leaves sometimes 17 millimeters broad; flowers not seen; fruit roundish oblate, about 45 millimeters across, somewhat corrugate, 8 loculed.

Budwood and fruits of the cabugao were forwarded to the Bureau by Mr. A. M. Burton, from the Mountain Province. The writer did not have the opportunity of examining the fruit, of which, however, an excellent photograph was made, and, to date of writing the plants at Lamao not having bloomed there has been no chance to examine the floral characters. The general character of the plant and fruit indicates that the cabugao is a form of the alsem.

Through a typographical error in Bulletin No. 27, Plate XVI (*a*), the cabugao is credited to Bohol.

B. A. No. 2266 (Benguet, Mountain Province).

Citrus longispina. TALAMISAN.

(Pls. II*a*, III*a*.)

An arborescent, very thorny shrub about 5 meters tall, with numerous suckers and interlocking branches, the spines on the stems frequently 10 centimeters long; young growth bright green, nearly always angular; leaves 6.5 to 10 centimeters long, 3 to 4.8 centimeters broad, ovate to broadly elliptical, crenate; base obtuse to broadly acute; apex acute to rounded, usually emarginate; petioles 19 to 25 millimeters long, rather narrowly winged, though in large leaves the wings are up to 18 millimeters broad; flowers not seen; fruit roundish, somewhat flattened at apex, 58 millimeters in diameter, smooth, deep lemon colored; skin thin; locules 11 to 15; pulp very juicy, mildly acid, with a tinge of orange yellow, aromatic and pleasantly flavored; juice cells large, plump, blunt or pointed at one end; seeds rather few, of medium size, fairly plump, more or less reticulate, polyembryonic, and of poor germinating qualities.

The talamisan is exceedingly rare, and is found in cultivation in Bohol (one plant has been seen in Cebu) and is fairly productive. Excepting the mandarin, which is also of rare occurrence, it is much superior to all other citrus fruits grown in these two islands, and is eaten by the inhabitants; it is nevertheless very rare and of no economic importance at present. The fruit ripens in January and February, and is a poor keeper. Introduced into cultivation, the fruit of the talamisan could to advantage be used as an ade fruit, and with a little sugar it would make a good breakfast fruit. The dense growth of the plant, with numerous suckers, armed also with formidable spines, would make it a good live fence.

The talamisan, or tamisan as it is also called, is one of the most interesting citrus fruits that has come to the attention of the writer. Its angular growth, formidable spines, broad, some-

times almost orbicular, distinct leaves and fruit easily distinguish the talamisan from all other species in the genus.

B. A. No. 2529, 4833 (Bohol).

Citrus macrophylla. ALEMOW.

(Pls. III*b*, VI*c*.)

A tree attaining a height of 6 meters, of upright growth, and rather long, stout, sharp spines; leaves 14 to 18 centimeters long, 6 to 8 centimeters wide, elliptical to ovate, crenate to serrate; base rounded; apex acute; petioles 18 to 40 millimeters long, broadly winged, wings frequently exceeding 35 millimeters in width; flowers 4 to 7, in compact cymes, sessile, 18 to 22 millimeters in diameter; calyx cupped; petals 4 to 5, oblong; stamens 26 to 30; filaments nearly always free; ovary small, 13 to 16 loculed; style distinct; stigma club shaped, small; fruit 85 to sometimes exceeding 100 millimeters in length, attaining a weight of 500 to 800 grams, subglobose to roundish oblong, more or less compressed towards base, which is nippled and with stem inserted in a shallow cavity; apex flattened with a circular depression around the raised stigmatic area; surface greenish lemon yellow, rather rough, with transverse corrugations; oil cells small, sunken; skin comparatively thin; pulp grayish, rather dry, sharply acid, lemon flavored; juice cells rather slender, long, and pointed; seed medium large, short and plump, smooth, sometimes beaked.

The alemow is a very rare fruit occurring in cultivation in Cebu, and considered inedible even by the natives. The description of the flowers was made from fresh specimens collected in May. The tree is said to bloom later in the year during the rainy season having then larger flowers. Partly grown fruit was then seen on the tree and since mature fruit has been examined by the writer from December to late in February the alemow is evidently nearly if not quite everbearing.

The principal distinguishing features in this species are the large, broad leaves, the comparatively short but quite broad-winged petioles, the free rarely united filaments, and the quite large, peculiarly shaped fruit; it is thus apparently one of the links between the two branches of the genus, one of which has the filaments more or less united and the other the filaments free, being in the first group most closely related to the pomelo.

The alemow was first forwarded to the writer under the name of colo: Bulletin 27, Plate XIV.

B. A. No. 2510, 2377, 3677, 4820 (Cebu).

Citrus southwickii. LIMAO.

(Pls. III*e*, IV*c*.)

A thorny tree, with dense head and drooping branches, attaining a height of 6 meters; spines small but sharp, leaves 9.5 to 14 centimeters long, 36 to 53 millimeters broad, ovate to roundish ovate, conspicuously crenate,



(*a*) Talamisan (*Citrus longispina* sp. nov.).

(*b*) Tizon (*Citrus nobilis* var. *papillaris* Blanco).

(*c*) Primitive type of the Philippine pomelo (*Citrus decumana* L.).



(*a*) Talamisan (*Citrus longispina* sp. nov.).



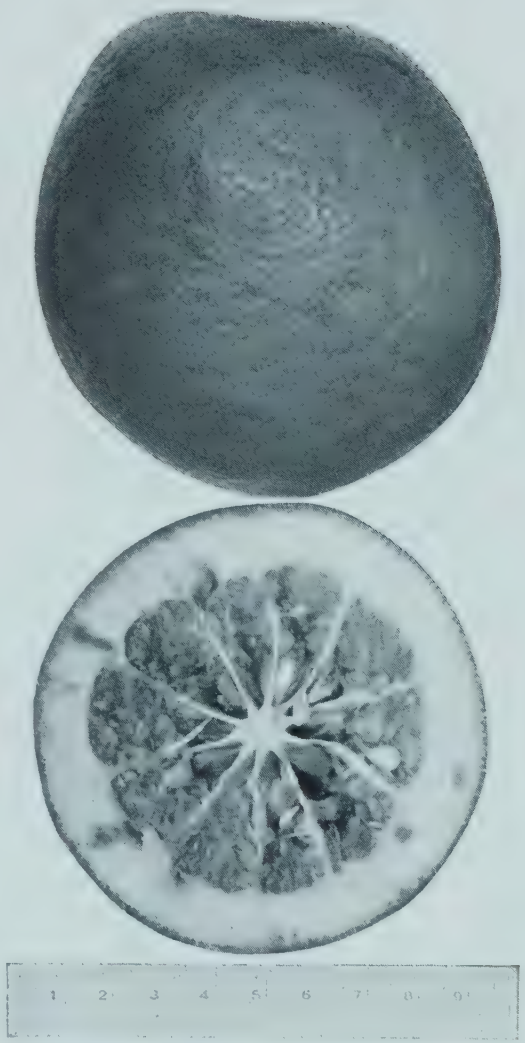
(*b*) Alemow (*Citrus macrophylla* sp. nov.).



(*c*) Limao (*Citrus limao* sp. nov.).



(*a*) Canci (*Citrus histrix* var. *boholensis*).



(*b*) Cabuyao (*Citrus histrix* DC. var. Amontay).



(*c*) Limao (*Citrus southwickii* sp. nov.).



(*a*) Canci (*Citrus histrix* var. *boholensis* sp. nov.).



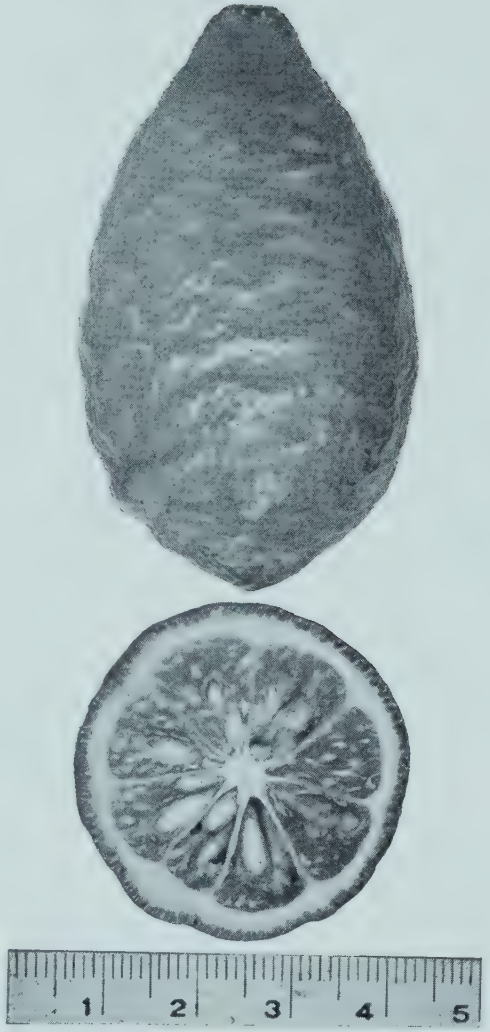
(*b*) Cabuyao (*Citrus histrix* DC. var. "Copahan").



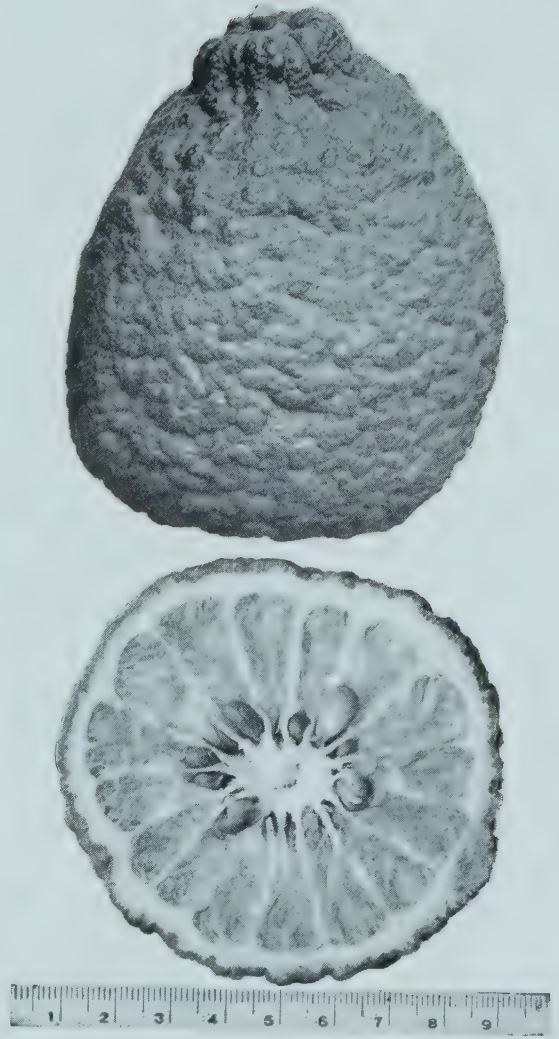
(*c*) Biasong (*Citrus micrantha* sp. nov.).



(*a*) Tihi-tihi (*Citrus medica* var. *odorata* sp. nov.).



(*b*) Biasong (*Citrus micrantha* sp. nov.).



(*c*) Alemow (*Citrus macrophylla* sp. nov.).



(*a*) Colo-colo (*Citrus pseudolimonum* sp. nov.).



(*b*) Samuyao (*Citrus micrantha* var. *microcarpa* sp. nov.).



(*c*) *Citrus micrantha* sp. nov. var. "Balincolong."

dark green and shining above, leathery; base acute; apex acute to obtuse, frequently emarginate; petioles 35 to 70 millimeters long, the wings 25 to 30 millimeters broad in large leaves, the average wing area somewhat less than half of the leaf blade; flowers 2 to 6, in compact axillary or terminal cymes, sometimes solitary, 14 to 20 millimeters in diameter, white, with trace of purple on the outside; calyx very small; stamens 22 to 28, free; ovary globose to oblate; locules 15 to 19; stigma almost sessile; fruit 45 to 55 millimeters long, 55 to 65 millimeters in equatorial diameter, oblate, with shallow cavity at apex, smooth, with slight longitudinal corrugations; lenticels sparse, small; oil cells usually raised; skin thin; pulp fairly juicy, sharply acid, bitter, with distinct aroma from *C. histrix;* juice cells short, plump, granulate, small, containing a small, greenish nucleus; seeds numerous.

The limao, though rare, is not uncommon in Bohol, where it is cultivated and has also been collected by the writer in Baganga, Mindanao. The flowers appear late in April and during the early part of May, with the fruit ripening in January and February; a few fruits nearly full grown were collected in May. No. 2049 has flowered irregularly from May to December. The fruit is not eaten, but used in washing by the Boholanos and is of no economic importance. The tree is evidently quite drought resistant, and succeeds well in very scanty soil underlaid with limestone.

The limao belongs in that group of the citrus fruits having free filaments, the most conspicuous characters being the compact growth of the crown, the dark-green, thick, and distinct leaves, the almost sessile stigma, and the attractive, oblate, regular-shaped fruit with its many locules, exceeding in number those in all other citrus fruits known to the writer. This species has been named in honor of Mr. E. F. Southwick, elsewhere referred to in the paper.

B. A. No. 2049 (Baganga, Mindanao), 2504, 4823 (Bohol).

Citrus histrix DC. CABUYAO.

(Pl. V*b;* fig. 1.)

A thorny tree, sometimes exceeding 6.5 meters in height; spines medium large and sharp; leaves 13.5 to 18 centimeters long, 4 to 6 centimeters broad, ovate to oblong ovate, coriaceous, dark green and shining above, crenate; base rounded to broadly acute; apex acute, sometimes emarginate; petiole 5.5 to 8 centimeters long, broadly margined, sometimes 4.5 centimeters wide, wing area inferior or equal to sometimes exceeding leaf area; flowers 4 to 7, in axillary or terminal, compact cymes, 17 to 28 millimeters in diameter; calyx small, not cupped; petals 4 to 5, oblong ovate, white, with trace of purple on the outside; stamens 30 to 36, equal, free, with abundant pollen; ovary rather large, globose, 13 to 18 loculed; style short and stout; stigma knob like; fruit subglobose to short pyriform or turbinate, attaining a length of 9 centimeters and a diameter of 7 centimeters;

surface smooth; color greenish yellow to lemon yellow; rind medium thick; pulp greenish, juicy, sharply acid, aromatic; juice sacs rather short and blunt, usually containing a more or less distinct nucleus; seeds usually many, flat, reticulate.

This fruit, commonly called cabuyao by the Tagalogs in central Luzon, is without question the "copahan" of Bohol. Near Manila the tree has been found in flower in September, while in Bohol flowers were collected in May. The fruit may be used in making ade, but is inferior to the lemon or lime. The native inhabitants eat it together with fish, and also use the fruit in washing. It is of practically no importance.

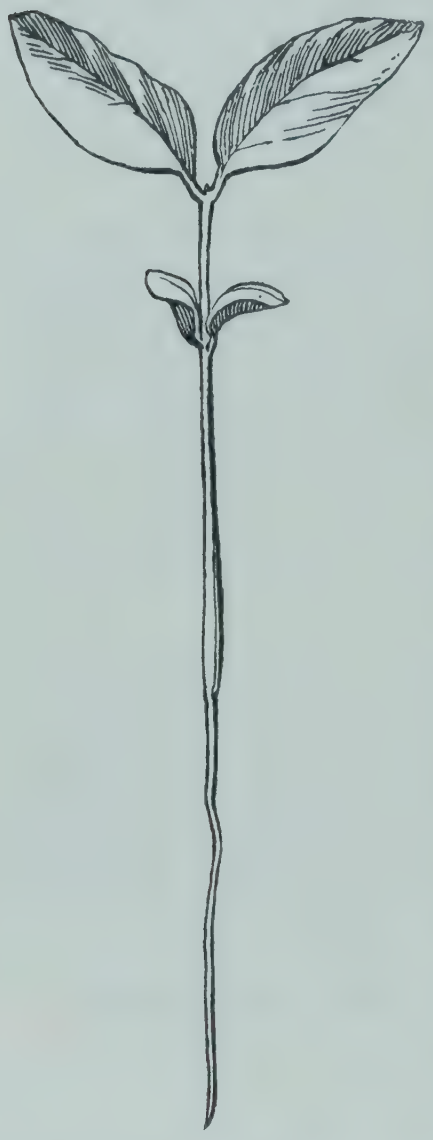


FIG. 1. Seedling of *C. histrix* DC., illustrating the distinct supraterraneous cotyledons.

The "amongpong," found in Bohol, and considered a distinct fruit from the copahan by the native inhabitants, differs chiefly in having only 26 to 30 stamens, and a large oblate ovary with a short and slender style. The first has not been examined by the writer and is said to be smooth and short, pyriform, 10 centimeters in diameter. Flowers examined in May.

"Calo-oy" is another fruit also found in Bohol considered by the inhabitants as distinct from the "copahan" and "amongpong." The leaf characters in the calo-oy scarcely differ sufficiently to entitle it to rank even as a subspecies; the flowers were just gone when the visit was made to Bohol. The fruit is said to be globose, smooth and about 8 centimeters in diameter.

"Amontay" (Pl. IV*b*) is still another form of *C. histrix* found in Bohol. This plant was also out of its flowering stage at the time of the visit. The fruit, forwarded to the writer in February by Mr. Southwick, is about 88 millimeters in diameter, irregularly globose, with flattened or depressed base, and rounded apex, smooth, lemon yellow; oil cells mostly raised; skin thick; the pulp, contained in 10 to 12 locules, juicy, and rather pleas-

antly aromatic; juice cells medium large, short and plump, containing a minute, greenish nucleus; cotyledons supraterraneous, distinct.

So far as observed, the amongpong, amontay and the calo-oy are not sufficiently distinct from the cabuyao to entitle them even to rank as subspecies.

The various forms above referred to are in the Bureau of Agriculture citrus collection at Lamao, represented as follows: Cabuyao, No. 739 (Lamao); copahan, No. 2570, 4835 (Bohol); amongpong, No. 2496, 4831 (Bohol); calo-oy, No. 4822 (Bohol); amontay, No. 2501, 4830 (Bohol).

Citrus histrix var. *boholensis*. CANCI.

(Pls. IV*a*, V*a*.)

A small tree, rarely exceeding 4 meters in height, with compact crown and small, sharp spines; leaves 9 to 12 centimeters long, 30 to 45 millimeters broad, ovate to elliptical ovate, crenulate, coriaceous; base broadly acute; apex acute to acuminate; petioles 35 to 45 millimeters long, 25 to 30 millimeters wide, wing area less than one-half of leaf area; flowers 2 to 6 in compact axillary cymes; petals white, with purplish tinge outside; stamens 20 to 23, equal, free; ovary quite large, oblate; locules 11 to 14; style short, distinct; stigma knob like; fruit 39 millimeters long, 46 millimeters in transverse diameter, oblate, smooth, lemon yellow; oil cells numerous, uniform, raised; skin medium thick; pulp quite juicy with very pronounced acidity; juice cells short, plump, and granular; seeds many, wedge shaped, monoembryonic; cotyledons supraterraneous.

The canci is found in cultivation in Bohol and is rather rare. Flowers were collected in May, and ripe fruits have been examined in January. The fruit is eaten with fish by the Filipinos, but is really so little grown that it has no economic importance. The fruit makes a fairly good ade.

While the canci undoubtedly belongs to *C. histrix* yet an examination of its parts shows that it is very distinct from that species as already described. In the leaves, the comparatively short petioles with small, cuneiform wings, as compared with the oblong-spatulate, broad-winged petioles in the cabuyao, etc., is very noticeable; the stamens are 20 to 23 only in the canci, while the locules are 11 to 14, and the fruit is shorter than broad unlike that in *C. histrix*. Everything considered the plant is apparently an intermediate type between *C. histrix* and *C. webberii*.

B. A. No. 2525, 4824 (Bohol).

Citrus histrix var. *torosa* Blanco. COLOBOT.

A spiny tree, attaining a height of 6 or more meters; young growth green with a tinge of purple; leaves 9 to 13 centimeters long, 3.5 to 5.5

centimeters broad, ovate to short ovate, bicrenate, dark green and glossy; base rounded, apex emarginate; petiole 4 to 7.5 centimeters long, 2.9 to 5 centimeters wide, oblong, with a broadly acute to obtuse base; wing area nearly equal to or frequently exceeding the leaf area; flowers 20 millimeters across, in axillary clusters of 2 to 6; pedicel slender; calyx small, not cupped; petals 4 to 5, white, with a tinge of purple on the outside; stamens 21 to 26, free, equal; ovary subglobose, 3 millimeters long, 11 to 14 loculed; style short, 1 millimeter long, distinct; fruit 48 to 55 millimeters long, and about 50 millimeters in transverse diameter, irregularly globose to oblate, usually compressed towards base, ending in a small nipple, more or less wrinkled, greenish lemon yellow; pulp greenish, fairly juicy, acid, scarcely edible; juice cells small, short, containing a small greenish nucleus; seeds small, oblong, reticulate.

This plant is the *C. torosa* of Blanco, which has been considered a synonym of *C. histrix*, and here raised to the rank of a subspecies. A comparative study of *C. histrix* and the variety *torosa* shows considerable differences between the two. *C. histrix* is generally larger in all parts; the wings of *C. h. torosa* are oblong, maintaining an almost equal width over a large part of the petiole, ending in a rounded to a broadly acute base, while in *C. histrix*, and in fact in all the species herein described with free stamens, the wings are more or less cuneate to elongate cuneate or oblong-spatulate, ending usually in an acuminate, sometimes an acute base, the one closest approaching the *C. h. torosa* in this respect being the "balincolong," referred to *C. micrantha*. The flower of *C. h. torosa* corresponds with that of *C. histrix* except that the former has 21 to 26 stamens as compared with 30 to 36 in *C. histrix*, which also averages more locules to a fruit.

B. A. No. 3665, 3666 (Batangas).

Citrus micrantha. BIASONG.

(Pls. V*c*, VI*b*, VII*c*.)

A tree attaining a height of 7.5 to 9 meters, with comparatively small but sharp spines; leaves 9 to 12 centimeters long, 27 to 40 millimeters broad, broadly elliptical to ovate, crenate, rather thin; base rounded or broadly acute; apex acutely blunt pointed; petioles 35 to 60 millimeters long, broadly winged, up to 40 millimeters wide; wing area sometimes exceeding leaf area; flowers small, 12 to 13 millimeters in diameter, white, with a trace of purple on the outside, 2 to 5, in axillary or terminal cymes; petals 4; stamens free, equal, 15 to 17; ovary obovoid, locules 6 to 8; style slender, distinct; fruit 5 to 7 centimeters long, 3 to 4 centimeters in transverse diameter, averaging 26 grams in weight, obovate to oblong-obovate, somewhat compressed towards base; apex blunt pointed; surface fairly smooth or with transverse corrugations, lemon yellow; skin comparatively thick; pulp rather juicy, grayish, acid; aroma similar to that of the samuyao; juice cells short and blunt to long, slender and pointed, sometimes

containing a minute, greenish nucleus; seeds many, flat, pointed, more or less reticulate.

The biasong has been collected in Cebu, Bohol, Dumaguete, Negros, and in the Zamboanga and Misamis Provinces in Mindanao, in all of which it is sparingly cultivated. The flowers were described from material collected in Bohol in May. Ripe fruit has been obtained in May, June, August, November, and February, indicating that the species is more or less everbearing. The fruit is used by the native inhabitants as a hair wash, is not eaten, and is of no economic importance.

Particularly noticeable in the biasong are the small flowers, with less stamens than any other species, and the oblong-obovate, few-loculed fruits.

The "balincolong," by the Filipinos regarded as quite a different fruit, found in Bohol and in Misamis, Mindanao, is a more robust tree attaining a height of 12 meters, and has longer wings and thicker leaves, with smoother fruits which sometimes are almost round, but these differences scarcely justify this form to rank as a subspecies even. Beginning in May, the balincolong (1982) has bloomed continuously at Lamao until date of writing (Dec. 18).

Biasong, B. A. No. 2502, 4829 (Bohol), Balincolong, No. 4834 (Bohol), 1981, 1982 (Misamis, Mindanao).

Citrus micrantha var. *microcarpa*. SAMUYAO.

(Pl. VII*b*.)

A shrubby tree, 4.5 meters tall, with slender branches and small, weak spines; leaves 55 to 80 millimeters long, 20 to 25 millimeters broad, ovate to ovate-oblong or elliptical, crenulate, thin, of distinct fragrance, base rounded to broadly acute; apex obtuse, sometimes notched, petioles 20 to 30 millimeters long, broadly winged, about 14 millimeters wide, wing area somewhat less than one-half of the leaf blade; flowers in compact axillary or terminal cymes, 2 to 7, small, 5 to 9 millimeters in diameter, white, with trace of purple on the outside; calyx small, not cupped, petals 3 to 5; stamens 15 to 18, free, equal; ovary very small, globose to obovate; locules 7 to 9, style distinct; stigma small, knob like; fruit 15 to 20 millimeters in diameter, roundish in outline; base sometimes nippled; apex an irregular, wrinkly cavity; surface corrugate, greenish lemon yellow; oil cells usually sunken; skin very thin; pulp fairly juicy, acid, bitter with distinct aroma; juice cells very minute, blunt, containing a small, greenish nucleus; seeds small, flattened, sometimes beaked.

The samuyao occurs sparingly in cultivation in Cebu and Bohol. Flowers were collected in May, partly grown fruits were also obtained, and ripe fruits have been collected in June, and from November to February, showing that the plant is more

or less everbearing. The fruit is used by the Filipinos as a hair wash, and is of no economic importance.

Throughout, the samuyao gives an impression of dwarfness, by its small size, weak spines, small, and thin leaves; the flowers are even smaller than in the biasong and the fruit is in all probability the smallest in the genus.

In Bohol a somewhat more vigorous variety of samuyao was found which is named "samuyao-sa-amoo." The fruits of samuyao-sa-amoo are a little larger, and smoother, and longer than broad, otherwise similar to the samuyao.

Samuyao, B. A. No. 2371, 2509 (Cebu), 2530, 4821 (Bohol); Samuyao-sa-amoo 2533, 4832 (Bohol).

Citrus medica L. CITRON.

A shrub or small tree, about 3 meters high, with a short, indistinct trunk and short, thick, irregular, straggling, thorny branches; bark light gray; thorns short, sharp, rather stout; young shoots smooth, violet colored or purplish, stiff; leaves large, 10 to 15 centimeters long, oval oblong, serrate or somewhat crenate, dark green above, lighter beneath; flowers small, axillary, in compact clusters of 3 to 10, often uninsexual; calyx small, cupped; corolla white within, tinged with purple on the outside; petals oblong, the tips incurved; stamens short, irregular in length, 40 to 45 in number; pistil small;[1] ovary 9 to 12 loculed or occasionally more; fruit lemon yellow, large, 15 to 22 centimeters long, oblong, rough or warty, sometimes ridged; apex blunt pointed; rind thick, white, except for the outer colored rim; pulp sparse; juice scant, acid, and somewhat bitter or sweetish; juice sacs small, slender; seeds oval, plump, light colored, smooth. Probably native to India, or it may have been introduced there from farther east, China or Cochin China. Extremely sensitive to cold.

The citron is the rarest of all the old cultivated citrus in the Philippines and is very seldom seen in the markets.

Citrus medica var. *odorata*. TIHI-TIHI.

(Pl. VII*a*.)

A small, thorny shrub, seldom exceeding 2.5 meters in height, with sharp, stout spines; young growth bright green; leaves 7.5 to 11 centimeters long, 4.3 to 6.5 centimeters broad, elliptical, rather thick and leathery, serrate, of distinct fragrance; base rounded; apex notched; petioles very short 4 to 6 millimeters long, not winged; flowers 1 to 4 in axillary compressed cymes, sessile, rarely exceeding 38 millimeters in diameter; calyx large, prominently cupped; petals 4 to 5, fleshy, white, with a tinge of purple on the outside; stamens 36 to 42, unequal, shorter than stigma; filaments united in groups of 4 to 6; pollen abundant; gynoe-

[1] In the above description the pistil is said to be small. Citron flowers examined by the writer have been found to have large pistils similar to those in *C. m.* var. *odorata* and *C. m.* var. *nanus*.

cium frequently aborted; ovary elevated on a bright green disk, large, 4 millimeters long, 13 to 14 loculed; style tapering from ovary, scarcely more slender, rather short; stigma large, knob like, and cleft; fruit 60 to 65 millimeters long, 7 to 10 centimeters in transverse diameter, weighing 300 to 475 grams, oblate, with a shallow basal cavity, and sometimes a mammilate apex, more or less ridged longitudinally, fairly smooth, clear lemon yellow; lenticels scattered, depressed; oil cells large, equal or a trifle raised; skin rather thick; pulp grayish, rather dry, sharply acid, of lemon flavor; juice cells long and slender; seeds many—sometimes 125 in a single fruit—short, broad, and flattened.

The tihi-tihi is a rare plant found in cultivation in Cebu and Bohol; one plant has been seen in Misamis, Mindanao. The plant is very precocious, fruiting as early as the third year from seed, everbearing, and is used by the Filipinos in washing the hair. It is not eaten, and is of no commercial importance.

The tihi-tihi differs from the citron in its green, tender, highly aromatic growth, the leaves having been found to contain 0.6 per cent essential oil as analyzed by the Bureau of Science. The fruit is strikingly different from the citron.

B. A. No. 19 (Cebu).

Citrus medica var. *nanus*.

A small, thorny shrub, rarely exceeding 2 meters in height, with small, sharp spines; leaves 7 to 11 centimeters long, 2.5 to 4.5 centimeters broad, narrowly oblong ovate to elliptical oblong, serrate, darker above than beneath; base rounded; apex frequently notched; petiole 5 to 7 millimeters long, wingless; flowers 2 to 10, in axillary or terminal, rather loose cymes, 3 to 4 centimeters in diameter; calyx large, cupped; petals linear oblong, with tips slightly incurved, white, with trace of purple on the outside; stamens 36 to 50, unequal; filaments usually united into groups, sometimes free; gynoecium sometimes wanting; ovary large, oblong, 10 to 12 loculed; style not distinct, of nearly the same thickness as ovary; stigma large, superior to anthers, knob shaped; fruit 65 or more millimeters long, 55 millimeters in diameter, ellipsoid to almost roundish, pointed at apex, lemon yellow, smooth; rind medium thick; pulp grayish to greenish, acid, rather dry; juice cells long and slender, almost linear; seeds many, rather small, flattened, smooth.

The plant is rather common in the Archipelago, and has been noted in Tarlac, Pampanga, Bulacan, Laguna, and Cebu. It is frequently grown and fruited in small pots, and is probably the smallest species in the genus. It is surprisingly productive and precocious, fruiting as early as the second year from seed, and is practically everbearing. The fruit is eaten by the Filipinos but is too dry to be cultivated for the flesh and the skin is too thin for utilization as citron peel.

B. A. No. 27 (Cebu), 2384 (Laguna).

Citrus limonum Risso. LEMON.

A small tree 3 to 6 meters in height, with rather open head of short, round or angular branches, thorny; bark grayish; young shoots purplish, smooth; leaves evergreen, alternate, 50 to 75 millimeters in length, ovate oval, sharp pointed, light green, margin serrate; petioles entirely wingless; flowers solitary, occasionally in pairs, axillary, on distinct peduncles; calyx persistent, segments 4 or 5; corolla large, 38 to 50 millimeters across, white inside, purplish outside; petals oblong, spreading, strongly reflexed; stamens 20 to 26, separate, or more or less united in small groups; ovary considerably elevated on a prominent disk, 7 to 10 loculed; fruit ripening at all seasons, ovoid or oblong, and pointed at both base and apex, about 75 millimeters long, smooth or rough, light yellow in color; rind thin, flesh light colored; pulp acid; juice sacs long and pointed; seeds oval, pointed at the micropylar end, quite smooth. Native of the same regions as the citron.

The true lemon is very rarely cultivated in the Philippines and all lemons used are imported from California, Australia and Spain.

Citrus pseudolimonum. COLO-COLO.

(Pl. VII*a*.)

A thorny shrub, 3 meters tall, with interlocking branches, and short, sharp spines; leaves 8 to 11 centimeters long, 40 to 45 millimeters broad, elliptical to oblong-ovate, crenulate to serrulate; base rounded; apex obtuse, frequently slightly notched; petioles 18 to 25 millimeters long, with narrow wing margin, rarely exceeding 10 millimeters in width; flowers 1 to 5, in terminal or axillary short cymes, 28 to 35 millimeters in diameter, white, purplish outside; calyx cupped; stamens 30 to 37, nearly always free, unequal; ovary broadly obovoid, 14 to 18 loculed; style distinct; fruit roundish to pyriform, small, usually compressed at base; apex irregular; surface greenish lemon, more or less corrugate; oil cells raised; skin comparatively thick; pulp acid; juice cells small, short and plump; seeds undeveloped and sterile.

The colo-colo is another of these peculiar Philippine species with more or less winged petioles affiliated to the lemon, etc. Flowers were collected in May, and ripe fruit has been examined in January and February. The nearly always free stamens in a plant belonging to the same general group as the lemon is of interest.

Near the colo-colo is the "lombog," considered a distinct fruit, also found in Bohol. This variety is less vigorous than the colo-colo and also differs from the plant in having narrower wing margins and 21 to 28 stamens and 9 to 11 locules. The fruit is said to be about 4.5 centimeters in diameter and similar in shape to that of the colo-colo.

The "kunot" is a third variety considered distinct by the Boholanos that also may be referred to *C. pseudolimonum*.

To *C. pseudolimonum* may perhaps also be referred a thorny, arborescent shrub, attaining a height of 4.5 meters, found in Siquijor, a little island south of Negros. Material of this was collected in August, 1912, by the writer, at which time the tree bore partly grown, oblong, rough, small fruits. The plants at Lamao have flowered during the last two months but have not set fruit. The principal difference in this variety from the colo-colo and lombog is in the number of stamens, here 36 to 41.

The fruits of *C. pseudolimonum* have no economic value.

Colo-colo, B. A. No. 2535, 4825; Lombog, No. 2498, 4827 (Bohol), 1953 (Siquijor).

Citrus limetta Risso. LIME.

A shrub or tree of straggling habit, with small, stiff interlocking or drooping, thorny branches, the thorns small, sharp, numerous; bark grayish brown; young branchlets light green, becoming darker with age; leaves elliptic-oval, glossy green in color, margin slightly indented; petioles margined; flowers small, produced in axillary clusters of 3 to 10; calyx small, four to five pointed; corolla white on both inner and outer surfaces; petals 4 to 5, oblong, fleshy; stamens small, 20 to 25, united in a number of groups; ovary about 10 loculed; fruit rounded or oblong, frequently mammilate, light yellow; rind thin; pulp greenish, acid; juice sacs small, slender, pointed; seeds small, oval, pointed. Native to India and southeastern Asia.

The lime, in Luzon known as "dayap," ranks third in importance among the citrus fruits cultivated in the Philippines, and now and then excellent fruit is found in the market, showing what could be done in grwing first-class fruit if pains were taken to do a little selection work and plant budded trees.

Citrus limetta var. *aromatica.*

A spiny shrub, with rather slender, willowly, drooping branches, and sharp spines; young growth light green, of pleasant and distinct odor when bruised; leaves 7.5 to 10 centimeters long, 3.5 to 5 centimeters broad, ovate oblong to elliptical, serrate to crenate, dull green above; base rounded to broadly acute; apex frequently notched; petiole 6 to 19 millimeters long with a narrow wing margin; flowers solitary or in cymes to 4, terminal or axillary, 28 to 35 millimeters across; calyx rather large, cupped; petals 4 to 5, white with a trace of purple on the outside; stamens unequal, 28 to 32, more or less united; ovary large, oblong, 12 to 13 loculed; style not distinct as in *C. aurantium* but rather similar to that in *C. medica,* a trifle more slender than the ovary; fruit 5 centimeters long, 4 to 4.5 centimeters across, roundish to roundish oblong, lemon yellow, smooth; skin thin; pulp pale green, juicy, sharply acid, sometimes almost bitter; juice cells long, slender and pointed; seeds very numerous, small and plump, polyembryonic.

This form seems to be fairly well distributed and material has been propagated at Lamao from such distinct points as Mindoro, Palawan and Benguet. Unquestionably a lime, it is quite distinct from the ordinary lime in habit, and in the aromatic tender foliage and purplish-petaled flowers on the outside, which are larger than those in the lime, the number of stamens also exceeding those of the lime.

B. A. No. 741 (Palawan), 1749 (Mindoro), 2182 (Benguet).

Citrus excelsa. LIMON REAL.

A thorny, tall shrub of vigorous growth, straggly habit and interlocking branches, with stout, long, sharp thorns; young growth purplish; leaves 9.5 to 16 centimeters long, 4.5 to 7 centimeters wide, elliptical oblong to ovate oblong, crenate to serrate, thick and leathery; base rounded; apex retuse; petiole 19 to 37 millimeters long, quite broadly winged, in large leaves the wings frequently exceding 2 centimeters in width; flowers 3 to 7, in axillary, rather loose cymes, 36 millimeters in diameter; calyx medium large, cupulate; petals showing trace of purple on the outside; stamens 34 to 35, unequal; filaments occasionally free, usually united into groups of 2 to 6; ovary roundish, 10 to 14 loculed, 4.5 millimeters across; style distinct, 5 millimeters long; stigma large; fruit 5 to 7.3 centimeters long, 5.5 to 7.5 centimeters in equatorial diameter, weight 115 to 225 grams; form subglobose; base rounded; apex flattened; surface smooth, greenish to clear lemon yellow; skin thin; pulp greenish to grayish, in good varieties very juicy, mildy acid, and of excellent flavor; juice cells long, slender and pointed.

Plant material of the limon real has been collected in Tarlac, Bontoc, and Bohol, and the fruit is at rare intervals offered for sale in small quantities in Manila.

The name of the plant, "Royal lemon," indicates the esteem in which the fruit is held by the people, and while it is unfortunately true that most fruits tested have been too dry to be of any value, yet in the best types the fruits in quality and aroma surpass all lemons and limes that the writer has had the opportunity to sample. With its robust, thorny growth, large leaves and broad-winged petioles and considering its affinity to the lime and lemon together with the roundish oblate fruit with 34 to 35 stamens as against the 20 to 26 in those species and with its 10 to 14 locules, this plant is apparently as distinct from the lemon and lime as these species are from each other.

B. A. No. 1727 (Bontoc?).

Citrus excelsa var. *davaoensis.*

A thorny, arborescent shrub of straggly habit, with interlocking, drooping branches, and of vigorous growth; young growth green with tinge of purple; leaves 8.5 to 13.5 centimeters long, 3.8 to 5 centimeters wide, ovate to oblong ovate, crenulate to serrulate; base rounded; apex some-

times retuse; petiole 16 to 30 millimeters long, with wings ordinarily narrow, in large leaves sometimes 15 millimeters wide; flowers not seen; fruit 6.4 centimeters long, 8 centimeters in equatorial diameter, weighing 317 grams, oblate; base rounded; apex flattened to depressed, wrinkled, with a circular depression around the raised stigmatic area; surface otherwise fairly smooth, lemon yellow; skin thin, central cavity large; pulp contained in about 13 locules, light colored, quite juicy, sharply acid, and of good flavor; juice cells long and slender.

Ripe fruit of this species has been received from Davao, Mindanao, in December and January. The fruit is perhaps too large for retail trade, but might possibly be utilized in the manufacture of lime juice and allied products.

Full-grown plants of *C. excelsa* or the variety above described have not been seen, but *C. e. davaoensis* appears to be smaller than *C. excelsa* in all respects, the fruits excepted. There has been no opportunity for an examination of the flowers but so far as observed the plant appears more closely related to *C. excelsa* than any other species herein described.

B. A. No. 1009 (Davao, Mindanao).

ECONOMIC VALUE OF THE NEW OR LITTLE KNOWN SPECIES.

The horticulturist and plantbreeder, ever on the alert for new plant material that may enhance his profits, extend the cultivable area of his crop, or be used in making new cross combinations, will naturally ask himself of what value are these new plants and fruits. Briefly stated, it may be said that the "Tizon" is a dessert or breakfast fruit of high, if not perhaps the highest, order, its main defect being the unsightly basal projection. Then, as stated elsewhere, the best "limon real" is unsurpassed in quality for "ade" making. Perhaps third in importance are the better types of the alsem for the manufacture of citric acid, etc., and it might find a sale in competition with the lemon and lime, depending to a great extent upon its keeping qualities. The juicy, thin-skinned, and few-seeded talamisan may find lovers as a breakfast fruit and is also of the right size for an ade fruit. If cultivation would increase the juiceness of the panuban, this fruit may find favor with many. A good marmalade may be made of the calamondin. The above species or varieties have more or less of a future on account of their pomological merits, and the plant breeder, by crossing them and the cabuyao and canci with old cultivated species, might obtain valuable results.

There is also the prospective value of the new species as stocks. To determine the congeniality of these species and the

old cultivated citrus fruits and their value as stocks under various soil conditions would of course require the labor and close observations of many years.

The calamondin is quite drought resistant and would probably dwarf the scion. One year old buds of the pomelo, lime, mandarin and orange at Lamao have made satisfactory growth, the buds taking without difficulty. The cabuyao is a very vigorous tree and is also drought resistant. It has recently been budded with the cultivated citrus fruits, the buds "taking" very well. The orange has been budded on the alsem, resulting in a good growth, being now (December, 1914) nine months old. During the trip to Bohol in May, the limao, growing in a coraline lime-stone formation overlaid with a little humus, the exact counterpart of the Bahama Islands or the "hammock lands" in southeast Florida, impressed the writer as one of the best examples of drought resistance among citrus fruits under such conditions. The talamisan also appeared quite drought resistant, and is furthermore of value as a live fence because of its large spines.

The "limon real" is of great vigor and hence may be a desirable stock for certain varieties and under certain conditions.

BY-PRODUCTS OF SUGAR MANUFACTURE.

By Cleve. W. Hines, M. S., *Station Superintendent.*

In various lines of manufacturing there are certain by-products which, years ago, constituted a waste and great loss, but which now under modern methods have become in many cases of considerable importance.

This is especially true with the sugar industry. Extreme care and attention is required to keep the balance on the right side of the ledger, and often the proper handling of the by-products forms the deciding factor between success and failure. In order to build up a great sugar industry in these Islands, more attention must be given to the details of the work, and many of the present losses must be turned into profits before great progress can be expected.

CANE TOPS AND TRASH.

First in the series of by-products in the manufacture of sugar, comes cane tops. The amount of this material produced per hectare will depend upon various factors, including the variety of cane, its stage of maturity, etc. The less of these tops, of course, that may be produced for a given amount of cane, the better it will be for the growers, nevertheless they have a good feeding value if properly handled.

Professor Dodson,[1] director of the Louisiana Experiment Station, states that he found cane tops to have the following composition:

	Per cent.
Protein	1.53
Fat	0.41
Carbohydrate	15.62
Fiber	8.87
Water	71.50
Ash	2.07

The fiber content would be slightly higher and the water content lower, for tropical cane, since maturity is completely

[1] Paper read before the Louisiana Sugar Planters Assn., June 12, 1913.

reached before harvest begins. It may be seen from the above analyses that this makes a most excellent feed for work animals. Certainly greater advantage should be taken of this feeding stuff than is usually done, since there is a scarcity of pasturage near the end of the harvest season and the animals become needlessly thin on account of lack of feed. At present very little of this material is utilized, but instead is burned on the field with the rest of the trash. If the tops are removed and used as a stock feed, only the leaves and pieces of stalk remain, and these make a good fertilizer for cane lands.

It is the general custom in these Islands to burn all of this material as soon as the crop is harvested. The object of this burning is to destroy any insects that may be present, as well as to facilitate subsequent cultivation. In the writer's opinion neither of these reasons is sufficiently well based, since in this country large numbers of troublesome cane insects are not found. If they were present in sufficient quantities, the trouble could be handled by placing the trash between the rows and properly treating it before plowing it under. This should be the method of disposing of the trash at all times. In this manner the waste material could be utilized, and the organic matter would be even more valuable than that contained in many of the commercial fertilizers. The nitrogen contained, which amounts to from 0.5 to 2 per cent, would be practically all saved, while with the burning method this is completely lost.

In Louisiana, cotton-seed meal forms one of the principal nitrogenous fertilizers for cane lands. This material costs from ₱50 to ₱75 per ton and Dr. Stubbs,[1] in his research, found that the trash burned from each ton of cane caused a loss of nitrogen equal to that contained in 27 pounds of cotton-seed meal. Besides this loss of nitrogen encountered in the burning of the trash, the organic matter which would later form humus is completely destroyed. Soils would retain moisture better during the dry season and be more easily handled if the conservation of organic matter were given greater attention. There is also a great injury done to the remaining stumps and top roots by this burning which is very detrimental when the field is to be used for a ratoon crop. Where cane is badly infested with destructive insects, it is quite another thing. This again brings up the fact that the cane points should be treated with chemicals before planting, in order to complete the work of destroying these insects.

[1] Cultivation of Sugar Cane, by Dr. Stubbs.

USE OF ASHES.

The ash of sugar cane constitutes the mineral matter that has been taken out of the soil. This usually runs about 0.48 per cent of the total weight, according to Payson's classical analyses. Chemically this contains the following: silica, iron, aluminum, lime, magnesia, potash, sodium, phosphorus, sulphur, chlorine, oxygen, water, etc. Of these various elements, the phosphorus and potash are the most valuable to the planter. Lime is also useful for many soils in correcting the acidity, and occasionally in supplying that element, when it happens to be lacking in a particular soil.

The cost of different fertilizers is governed by the percentage of these plant-food elements contained. Phosphoric acid is worth $0.05 per pound (₱0.22 per kilo) in crude fertilizers. At this rate the value of this element recovered from a crop of 75 tons of cane per hectare would be from ₱10 to ₱12.

Potash is valued at about ₱0.26 per kilo and that removed with a crop of 75 tons would cost about ₱25. The lime contained is a cheaper element but will not act as a detriment on any soil, while on many it will be found very helpful.

In spite of the great deficiency in these elements in the cane lands here, and the high cost of commercial fertilizers, this waste material is not only neglected at the majority of the factories but is actually thrown away, yet the same elements that command a high price in commercial fertilizers are contained in these ashes.

FILTER-PRESS REFUSE.

In the defecation of cane juice, certain chemicals are often used to precipitate the impurities, which are removed from the subsiders after the clear juice has been drawn off, and sent to the filter presses, where it is filtered through heavy cloths. This material contains coarse particles of bagasse together with other impurities including the lime and phosphoric acid which were used in this work. The composition of the material depends upon the original composition of the juice and the amount of the different chemicals that has been used in the clarification. In any event, it makes a most valuable fertilizer because of the organic matter, nitrogenous bodies, phosphoric acid, and lime that it contains. This organic material is an ideal substance to be applied to the worn-out cane lands (which consist almost entirely of mineral substances) since it induces bacterial action, and during its decomposition certain acids are freed, such as

carbonic, nitric, and organic acids. These have the power to act upon the mineral constituents and thus liberate other plant-food elements. The filter-press mud can very well be mixed with the bagasse ashes, and scattered about the cane rows as an almost complete fertilizer for sugar cane, the only element lacking being nitrogen, which was lost in the burning of the bagasse.

It will be remembered that in the synthesis of sucrose, which consists of carbon, hydrogen, and oxygen, there are none of the plant-food elements used which are sought for in commercial fertilizers. These are used only in building the fibrous stalk of the cane and they may all be recovered in the bagasse and cane-juice impurities. The carbon, hydrogen, and oxygen which are used practically all come from the air and water.

It is a custom to-day to cart this ash to piles or depressions some distance from the factory. In some places it is thrown into the river, or cast into the sea—an absolute loss.

Planters must not depend upon commercial fertilizers for their supply of plant-food material, when there is such an abundance of natural fertilizer being wasted. The cost of the artificial fertilizers in many cases is considered prohibitive and often unnecessary. In order to build up a great sugar industry here, the material at hand must be used, while money should be spent for modern apparatus and equipment.

MOLASSES.

The dark-colored viscous substance remaining after the large crystals of sucrose have been removed is called molasses. This contains small crystals of sucrose, which has passed through the perforations of the centrifugal screens, sucrose in solution, glucose, fructose, and other organic substances, such as pectin bodies, albumenoids, coloring substances, etc., besides the inorganic matter constituting the ash upon incineration of the molasses.

The composition of the molasses varies with the working of each factory, also with the condition of cane, time of harvest, etc. The juice from green cane and that which has reached ultramaturity will contain a higher percentage of invert sugar and organic non-sugars than a properly matured cane. Then factories that have ample boiling-house provision, and crystallizers as well as magma tanks, will be able to send out a molasses with lower purity, thus recovering more of the crystallizable sugar.

In any case there will be some molasses produced, and this constitutes a valuable sugar-house by-product, if properly cared for. It may be disposed of in one of several forms, namely, as a human food, a stock feed, a source of alcohol, factory fuel, and a fertilizer.

Cane molasses as a human food.—For many years low-grade cane molasses has been used as a human food in the United States. It was originally sold under the name of New Orleans molasses, but in recent years a number of companies have employed clarifying and bleaching agents and thus turned out a very fancy article, under various trade names, for baking purposes. With the boiling at low temperatures practiced to-day, there is little or no caramel formed during this work, and consequently it is only necessary to clarify and bleach the organic nonsugars, in order to make a salable molasses. The bleaching is usually accomplished by the use of a hydrosulphite, either in the form of sodium or calcium, but sometimes only the sulphurous acid gas is used.

The bleaching effect of none of these reagents is permanent, especially when the product is exposed to the air and light. Such chemicals must therefore be used with great caution, and as late in the process as possible. Care must be exercised too that an excessive amount is not employed, since an undesirable tint is liable to result as well as an excessive amount of the sulphites to be admitted, which is not permitted by the Pure-Food Law. It is astonishing how much of this low-grade molasses is thus manufactured and used in the United States for cooking purposes, and what a high price this product commands.

Cane molasses as a stock feed.—Perhaps more of the exhausted molasses is used for this purpose in these Islands than for any other.

Ordinary molasses contains from 30 to 35 per cent of sucrose and almost as much glucose. These being purely carbohydrates, it is necessary to combine them with some protein-bearing feed in order to make a perfect ration. Many leguminous plants, such as alfalfa, cowpeas, peanut vines, etc., may be cut fine and used as an absorbent for molasses. This makes a most excellent feed as it contains a sufficient amount of roughage, and at the same time offers a balanced ration if properly composed. In this country there is a great amount of exhausted cake from the coconut-oil factories, which is exported to Europe each year. There is no good reason why this should not be used as an absorbent for the molasses in making a concentrated feed, which

could be transported to various parts of the Islands or exported abroad for stock.

To-day the Philippines are dependent upon Australia and other countries for many thousand head of cattle each year. The by-products from sugar factories are thrown into the rivers or flushed away from the factories through drains, and the leaves and tops of the cane are burned on the ground in order to facilitate cultivation. In the attempt to grow our own beef, these feeds should be an important factor.

Cane molasses as a source of alcohol.—Alcohol can be made from a great variety of substances containing the necessary constituents, viz, carbon, hydrogen, and oxygen.

Of the numerous alcohols possible, ethyl alcohol is the one ordinarily sought and the easiest produced. This alcohol is represented by the following chemical formula: C_2H_5-OH.

While glucose is the substance which may be easily transferred into alcohol by fermentation, sucrose may also be used, providing it is first changed into glucose or invert sugar. Even cellulose and starch may be used after being transferred into reducing sugars.

The process of changing glucose into alcohol and carbon dioxide is called fermentation and is accomplished by a minute organism. Sucrose will not directly ferment, consequently it must first be changed into glucose. This is usually accomplished by an enzyme which is secreted by a ferment.

The following chemical formula will serve to show the steps necessary to pass from sugar to an alcohol:

$$\underset{342\ \text{M. W.}}{C_{12}H_{22}O_{11}\ \text{(sucrose)}} + \underset{}{H_2O\ \text{(water)}} \quad \text{Presence of an}$$

$$\text{enzyme} \rightarrow \frac{\text{Invert sugar}}{(C_6H_{12}O_6\ \text{(dextrose)}\ \underset{180\ \text{M. W.}}{C_6H_{12}O_6\ \text{(levulose)}})\ \ \underset{180\ \text{M. W.}}{}}$$

$$\rightarrow \underset{184\ (2\ \text{M. W.})}{C_2H_5\text{–OH (ethyl alcohol)}} + \underset{176\ \text{CM. W.}}{4CO_2\ \text{(carbon dioxide)}}$$

The theoretical yield then of alcohol from sucrose would be 53 per cent and from invert sugar 51 per cent. In practice, however, this yield would not be experienced on account of the yeast converting some of the sugars into substances other than alcohol and carbon dioxide. These will consist mostly of glycerine and succinic acid and will amount to 4 or 5 per cent.

Since the working conditions determine to a very great extent

the yield of alcohol, it is obvious that a thoroughly efficient person should be in charge of this work. In the selecting of cultures for the fermenting, the manufacturer should use only the purest, otherwise acetic acid and other foreign substances will be formed during fermentation, thus decreasing the yield of the alcohol as well as lowering its purity.

Where the percentage of sucrose and glucose of a molasses is known, it is a simple matter to calculate the theoretical amount of alcohol to be recovered and by knowing the efficiency of the factory, a factor may be obtained which multiplied by the theoretical yield will give the true amount of alcohol to be expected. In this manner it is easy to determine the price that may be paid for any molasses.

The separation of the alcohol from the water and dirt (lees) is accomplished in an apparatus termed a "still." In this the liquor is heated by steam which causes the alcohol to evaporate. Since ethyl alcohol boils at a temperature of 78° or a little higher, depending upon the percentage present, it may be separated from the water and impurities during the evaporation, and recovered from the coils of the condenser in a fairly pure state.

There is always, however, more or less water vapor escaping with the alcohol and consequently it is impossible to secure absolute alcohol without after-treatment, although in the modern still a very high grade is often recovered in the first distillation.

In this connection the strength of alcohol is usually determined by referring it to "proof," which is an old English system used before modern methods of testing spirits were available. In its original application, gunpowder was moistened with the spirit and the mixture subjected to the flame of a match. When just enough alcohol was present to set fire to the powder, it was said to be "proof spirit." If not enough alcohol was present to accomplish this, it was said to be "under proof," and when the gunpowder was lighted easily by it, it was said to be "over proof."

By an act of the English Parliament, the term "proof spirit" was fixed as one which contains exactly $\frac{12}{13}$ of an equal volume of water (distilled) at 51° F., which represents 57.1 per cent of alcohol by volume, or 49.3 per cent by weight.

The simplest method of determining the percentage of alcohol is by the use of a gravity spindle for liquids lighter than water, and by referring to the accompanying table for this purpose, the percentage of alcohol may be ascertained.

Table for calculating the percentage of alcohol.[a]

Volume.	Specific gravity at—		Volume.	Specific gravity at—		Volume.	Specific gravity at—		Volume.	Specific gravity at—	
	15.56°/15.56°	25°/15.56°		15.56°/15.56°	25°/15.56°		15.56°/15.56°	25°/15.56°		15.56°/15.56°	25°/15.56°
P. ct.			*P. ct.*			*P. ct.*			*P. ct.*		
1	0.9985	0.9970	26	0.9698	0.9655	51	0.9323	0.9246	76	0.8745	0.8665
2	.9970	.9953	27	.9691	.9646	52	.9303	.9226	77	.8721	.8641
3	.9956	.9938	28	.9678	.9631	53	.9283	.9205	78	.8696	.8616
4	.9942	.9922	29	.9665	.9617	54	.9262	.9184	79	.8664	.8583
5	.9930	.9909	30	.9652	.9603	55	.9242	.9164	80	.8639	.8558
6	.9914	.9893	31	.9643	.9594	56	.9221	.9143	81	.8611	.8530
7	.9898	.9876	32	.9631	.9582	57	.9200	.9122	82	.8581	.8500
8	.9890	.9868	33	.9618	.9567	58	.9178	.9100	83	.8557	.8476
9	.9878	.9855	34	.9609	.9556	59	.9160	.9081	84	.8526	.8444
10	.9869	.9846	35	.9593	.9538	60	.9135	.9056	85	.8496	.8414
11	.9855	.9831	36	.9578	.9521	61	.9113	.9034	86	.8466	.8384
12	.9841	.9816	37	.9565	.9507	62	.9090	.9011	87	.8434	.8352
13	.9828	.9801	38	.9550	.9489	63	.9069	.8989	88	.8408	.8326
14	.9821	.9793	39	.9535	.9473	64	.9047	.8969	89	.8373	.8291
15	.9815	.9787	40	.9519	.9456	65	.9025	.8947	90	.8340	.8258
16	.9802	.9773	41	.9503	.9438	66	.9001	.8923	91	.8305	.8223
17	.9789	.9759	42	.9490	.9424	67	.8973	.8895	92	.8272	.8191
18	.9778	.9746	43	.9470	.9402	68	.8949	.8870	93	.8237	.8156
19	.9766	.9733	44	.9452	.9382	69	.8925	.8846	94	.8199	.8118
20	.9760	.9726	45	.9434	.9363	70	.8900	.8821	95	.8164	.8083
21	.9753	.9719	46	.9416	.9343	71	.8875	.8796	96	.8125	.8044
22	.9741	.9706	47	.9396	.9323	72	.8850	.8771	97	.8084	.8003
23	.9728	.9692	48	.9381	.9307	73	.8825	.8746	98	.8041	.7960
24	.9716	.9678	49	.9362	.9288	74	.8799	.8719	99	.7995	.7914
25	.9709	.9668	50	.9343	.9267	75	.8769	.8689	100	.7964	.7865

[a] From United States Department of Agriculture Bulletin, No. 107, p. 203.

Molasses as a fuel.—Many experiments have been made, using this substance as a sugar-house fuel, and while ordinarily it may be better employed in some other manner, at the same time where no other provision is made for the use of this material, and where there is a scarcity of fuel as well, satisfactory results may be secured in its combustion if it is properly handled.

Waste molasses consists mainly of gums, sucrose, glucose, albuminoids, other organic compounds, water, and a small amount of ash.

Sucrose has the chemical formula of carbon 12 (atoms), hydrogen 22 (atoms), and oxygen 11 (atoms). The burning of carbon consists in uniting oxygen to that element, forming carbon dioxide. When hydrogen burns, the oxygen combines with it, forming water. During this oxidation, two atoms of hydrogen combine with one of oxygen, but in the molecule of sugar, these two elements are already present in this proportion, consequently only the carbon may be oxidized and thus give off heat. This is found to be true also of sucrose, reducing sugars, and many organic compounds.

An instrument called a calorimeter is used to determine the

amount of heat a substance will give off upon oxidation. Tests may be made on molasses in order to determine its value as a fuel, and thus a comparison may be obtained of a pound of this material and one of coal having a standard value.

The ash from the molasses contains a great deal of potassium and some magnesium, consequently care must be exercised in the burning of the molasses so that this material does not come in direct contact with the tubes of the boiler, since a heavy coating will be formed that will greatly lower the coefficient of heat transmission.

On account of the high potash content, these ashes make a valuable fertilizer, which should be mixed with the bagasse ashes and mud cake, and applied to the cane lands.

Molasses as a fertilizer.—While molasses is not used to any great extent as a fertilizer, there is no good reason why exhaustive experiments should not be carried out with this by-product on Philippine soils, when it is now being thrown into drains or wasted, until a better use is provided for the molasses.

Experiments have been made in Hawaii, Mauritius, and other places with this form of fertilizer, and very encouraging results were reported. The plant-food elements themselves contained in molasses are small in amount, since they are contained in the low percentage of ash after burning, except, of course, nitrogen, which will be entirely saved. Its main value, however, lies in the power to induce bacterial growth, which is so necessary in worn-out soils.

Among the organisms induced by these organic matters may be included certain azotobacter species, which contrary to other forms of plant life, have the power of using nitrogen from the air. Carbohydrates form especially good mediums for their development, and it has been found that the activities of these organisms are increased by an increased amount of this substance.

While excellent results have been attained by the use of low-grade molasses for fertilizer in other countries yet it remains for the planters here to determine results under Philippine conditions, and the best method of handling their material. In some places where irrigation water is applied, the molasses is mixed with the water and applied in the usual manner.

The plant-food material contained in molasses will vary somewhat with the methods of its production, clarifying agents previously used, etc.

The following table will indicate the composition of ash from different molasses:[1]

	1	2	3	4
	Mill sulphitation.	Diffusion sulphitation.	Open kettle.	Carbonitation.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Potash	49.48	52.20	51.48	50.16
Soda	.89	.80	1.11	.32
Lime	6.47	6.78	6.58	8.53
Magnesia	4.29	3.09	3.99	2.66
Iron oxide	.35	.33	.15	.47
Alumina	.30	.22	.13	.30
Silica	4.12	4.59	2.83	4.10
Phosphoric acid	3.71	3.80	2.12	.91
Sulphuric acid	10.79	6.72	10.94	11.18
Carbonic acid	7.49	11.19	13.06	15.78
Chlorine	14.00	11.95	9.10	4.59
	101.89	101.67	101.49	99.00
Deduct O minus Cl.	3.16	2.70	2.05	1.04
	98.73	98.97	99.44	97.96
Undetermined (carbon, etc.)	1.27	1.03	0.56	2.04
Alkalinity (cc. tenth normal per gram ash) ----cc.	80	93	95	109

In order to make a wise selection of the method of handling the different by-products the manufacturer must take into consideration many factors. Among them will be the quantity of his output, the facilities for handling it in any specified manner, the demand for different finished products to be made therefrom, etc. All of these and many other points must receive due consideration by a manager who expects to attain success in his work.

[1] **Bulletin 91, Louisiana Sugar Experiment Station.**

COFFEE IN THE PHILIPPINES.[1]

By P. J. WESTER, *Horticulturist in Charge of Lamao Experiment Station.*

PRELIMINARY REMARKS.

While it cannot be said that the Philippines have ever grown coffee on a scale that made it an important factor in the world's market, yet, before the advent of the coffee blight, coffee growing, from a Philippine point of view, was an industry of considerable magnitude and unquestionably of great promise. However, in the Philippines as in other parts of the eastern Tropics, the blight destroyed the coffee industry, and while in the last few years previous to the appearance of the blight there was an average annual export of about 7,000 tons of coffee, valued at ₱4,000,000, in 1913 the Philippines produced only 113,031 kilograms of Arabian coffee with an average production of 174 kilograms per hectare, the coffee imports during the same period amounting to 1,138,781 kilograms, valued at ₱816,744. The leading coffee-producing provinces of the Archipelago were, during 1913, the Mountain, 42,066 kilograms; Moro, 31,040 kilograms; Nueva Vizcaya, 5,792 kilograms; and Batangas, 5,319 kilograms. Varying quantities of coffee, less than 5,000 kilograms in any one, were produced in each of the remaining provinces, excepting Agusan, Bataan, Batanes, Ilocos Sur, Leyte, Pampanga, and Surigao, where coffee is not grown.

From a study of the coffee situation in the Eastern Hemisphere it is evident that Arabian coffee will never again become of importance in this part of the world, including of course the Philippines. However, it seems that a satisfactory substitute has been discovered in the robusta coffee. This variety, while not immune to the blight, is so resistant to the effects thereof that

[1] All statistics, and much of the information that applies specifically to robusta coffee have been adapted from "Robusta and Some Allied Coffee Species" by Dr. C. J. J. Van Hall, of the department of agriculture, Buitenzorg, Java, published in the Agr. Bul. of the F. M. S., Vol. I: No. 7, 1913, and from a review of a series of articles on robusta coffee by Dr. E. Wildeman, in the Monthly Bul. of Agr. Intelligence, etc., Vol. IV: No. 4, 1913.

the disease ceases to affect the profits of the crop, or at least very slightly.

This and other reasons, which will be explained later, have resulted in the planting of robusta coffee on a very large scale in Java and adjacent Dutch possessions, and the reports relative to this variety are such as to recommend it to the serious consideration of Philippine planters. The present paper has been prepared with a view of meeting the almost daily requests that reach this Bureau for information on the subject of coffee, and particularly to give some information relative to the robusta coffee, with which practically all planters in the Archipelago are unfamiliar. It might perhaps be well to state that propagation, handling of the plants from the seed bed to the plantation, culture, etc., are the same for both Arabian and robusta coffee, except where so stated.

ARABIAN COFFEE.

The decrease in the cultivation of coffee and the present status thereof in the Philippines show conclusively that Arabian coffee cannot be profitably grown here below an altitude of 800 meters. At and above this elevation the climate is so favorable for the growth of the plant that when kept in good condition it is capable of resisting the attack of the blight sufficiently to yield a profitable crop. Nevertheless, the planting of Arabian coffee on a large scale is not recommended even here, because the disease is everywhere present, waiting for a favorable opportunity to spread, and a drought, typhoon, or in fact anything that would devitalize the plants, would be sure to render them liable to a severe attack that might wipe out an entire plantation or district.

It is true that Arabian coffee grows below an altitude of 800 meters; in fact, coffee bushes are found at sea level, but a prospective investor should always remember that there is a very great difference between being able to merely *grow* coffee and to *produce it in such quantities that its cultivation becomes profitable.* This cannot be done at a low elevation. It is perhaps well to state here that exhaustive experiments have so far failed to yield a fungicide or spray by which the coffee blight can be satisfactorily controlled in the field.

Everything considered then, only in certain districts of the Mountain Province and on the table lands of Mindanao may Arabian coffee be successfully and profitably cultivated to any considerable extent.

ROBUSTA COFFEE.

Robusta coffee in Java.—When the blight appeared in Java, coffee growing was one of the most important industries in that island, and after the plantations had been destroyed by the disease, the Dutch Government, having failed to control the blight by repressive measures, instituted investigations with a view of discovering a blight-resistant coffee, in the course of which work several species were introduced and tested. Among these were Liberian coffee (*Coffea liberica*) and robusta coffee, considered by Wildeman to be a variety of *Coffea canephora*.

Robusta coffee was discovered in the Belgian Congo, and seeds were sent to Brussels, Belgium, and propagated, where plants were first offered for sale in 1901. Some of these plants found their way to Java. Like most new introductions the robusta coffee was at first looked upon rather askance, but as its greater climatological range as compared with that of Arabian coffee, and its productivity, precocity, and resistance to the coffee blight (*Hemileia vastatrix*) became apparent, it rapidly gained popularity—so rapidly in fact that the Javanese coffee plantations today consist almost entirely of robusta coffee. The fact that in 1909 the total crop of robusta coffee was only 183,000 kilograms, and that in 1911 9,650,000 kilograms were produced, with an estimated yield of 16,000,000 kilograms for 1912, and that during the period from 1907 to 1911, 24,521,000 robusta coffee plants were planted, is ample proof of its popularity in the Dutch East Indies.

Introduction into the Philippines.—Robusta coffee has not been introduced into the Philippines to any extent. Bearing trees are reported from Basilan, near Zamboanga, and a few plants are also growing at the Lamao experiment station in Bataan. The latter are in good condition with no indication of blight.

Soil and climate.—Robusta grows well from sea level to an altitude of 1,000 meters, doing best at an elevation ranging from 450 to 750 meters.

Less particular than Arabian coffee, the robusta thrives well on both light and heavy soils provided they have the necessary fertility. However, good drainage is essential for a good growth and therefore robusta should not be planted on sticky and very heavy, water-holding soils. Poor and sandy soils should also be avoided. This variety is also somewhat sensitive to drought and should be planted only where the rainfall is fairly evenly distributed, and where the dry season is of comparatively short duration. Generally speaking, where the soil conditions are

favorable, the cacao, abacá, and coconut growing districts of the Archipelago are perhaps better adapted than other sections to the culture of robusta coffee.

CULTURE.

Propagation.—The place selected for seedbed and nursery should be well drained, with a loamy soil, the richer in humus the better. A light bamboo frame should be erected above the nursery plot about 2.5 meters high, and covered with grass or split bamboo to provide about half shade. The land should be spaded thoroughly to a depth of 30 centimeters, and all stones, roots, etc., removed. One meter is a convenient width for seed and plant beds.

The seeds should be sown broadcast, not too thick, covered with not more than 1 centimeter of earth, and then watered thoroughly. Hereafter the seedbed should be well watered from time to time whenever the soil appears dry. Frequent light sprinklings that do not allow the water to penetrate more than a few millimeters below the surface are harmful rather than beneficial both in the seedbed and the nursery, in that they encourage a shallow root formation.

As soon as the first leaves are fully expanded the seedlings should be transplanted to the nursery beds, which should be prepared like the seedbed. If the land is poor it is well to spade in a liberal quantity of well-decayed manure or compost. The plants should be taken up carefully, the taproot nipped off with the thumb nail, and then transplanted with the aid of a pointed stick or small dibber spacing them 10 to 15 centimeters apart each way. In doing this care should be taken that the roots are not doubled up in the hole and that the soil is well packed around them. More plants should never be removed at one time from the seedbed than can be conveniently transplanted before they show signs of wilting, and the dug plants should not be left exposed until the roots dry out. The plants should be thoroughly watered before and after transplanting, and the beds kept free from weeds and watered as often as necessary.

Clearing and planting.—Wherever possible, the land to be planted in coffee should be stumped, and plowed once or twice, so that after the plants have been set out animal-drawn cultivators can be used to keep down the weeds. Thus the cost of weeding is lessened during the early years of the plantation while the plants are small. If plowing is not feasible holes 1 meter in diameter and at least 30 centimeters deep should be grubbed where the plants are to be set.

On moderately rich land robusta coffee should be planted 2.1 meters apart each way, 2,265 plants to the hectare; on very fertile land the distance may be increased to 2.5 meters, or 1,600 plants to the hectare.

Arabian coffee should be spaced from 2 to 2.5 meters apart or on poor lands even closer.

When the plants are 4 to 5 months old they should be about 20 centimeters tall and ready for transplanting. About one-half of the foliage should now be cut off; a trench should be dug at the end of the nursery bed about 20 centimeters or more deep; then a thin, sharp spade or bolo (cutlass) should be passed through the soil, underneath and around the plant, neatly severing all straggling roots, and leaving the plant in the center of a ball of earth. The plants should be set out in the field at the same depth at which they grew in the nursery, great care being taken not to break the ball. If the soil is so loose that it falls away from the roots in the removal from the nursery, great care should be exercised in not allowing the roots to dry out and in setting out the plant so that the roots fall in a natural position. In the course of the planting the soil should be firmly packed about the roots.

The sowing of the seed in a given locality should be so timed that the plants are ready for transplanting at the beginning of the rainy season in order to avoid the expense of artificial watering. If transplanted during the dry season the plants necessarily would have to be watered by hand from time to time until they are established.

Plants for shade.—As a temporary shade and cover crop of rapid growth while the coffee trees are small, perhaps no plant can compete with the cadios (*Cajanus indicus*). The plants may be cut down to serve as mulch whenever they grow too high, and may be expected to grow from the stubble twice before the plants die, provided they are not cut off too close to the ground.

In Java, where robusta coffee is more extensively planted than anywhere else, permanent shade is considered advisable. Malaganit (*Leucaena glauca*), a leguminous shrub which grows everywhere in the Philippines, seems to be preferred there to other plants for shade. It is planted alternately with the coffee plants and, as is the case with all plants utilized for shade, thinned out later according to need. Madre de cacao (*Gliricidia maculata*) and dapdap (*Erythrina indica* and *E. subumbrans*) are other leguminous trees readily obtainable in most localities and are adapted for shade.

Madre de cacao should be planted at the same distance as the

malaganit while the dapdap should be planted one plant to every two coffee trees. All these plants are readily propagated by cutting off limbs or branches 1 to 1.2 meters long and inserting them 20 to 30 centimeters deep in the ground during the rainy season. (This is most conveniently done by the aid of a crowbar.) In a limited way fruit trees, such as the soursop, custardapple, breadfruit, and jak may also be used as shade, and these should be planted from 6 to 12 meters apart according to size. The necessary shading between these trees while they are small may be provided by planting malaganit, etc.

Robusta coffee has also been successfully interplanted with coconuts. In this case the palms and coffee should of course be planted at the same time, the palms perhaps not closer than 9 to 10 meters apart, the coffee to be used as a "filler" between the coconuts. In this connection it is perhaps well to state that in Java robusta coffee is very frequently planted as a "catch crop" in the Hevea rubber plantations. Among the shade plants available to the Philippine planter, malaganit, dapdap, and "guango," or raintree (*Pithecolobium saman*), have given the best results in Java for the robusta with the following ratio yield of coffee: 4.75, 4.10, and 3.06.

Cultivation.—On level and well-cleared land, close attention should be paid to keeping the coffee plantation free from weeds during the first year or two by means of animal-drawn shallow cultivators, supplemented with hand-hoeing. Where the topography of the land or the presence of stumps renders this impossible the weeding must of course be done by hand. All weeds should be left in the field where they serve both as a mulch in preserving the moisture and to enrich the soil. As soon as the plants begin to shade the land they thereby aid in the weed eradication, and weeding then becomes less expensive.

Pruning.—If the trees are allowed to grow without pruning they become too tall (robusta coffee attains a height of 6 meters or more), and the topmost berries are then difficult to pick. Furthermore unpruned coffee trees (including robusta), have the peculiar habit of bearing their branches near the ground and at the top, leaving the middle bare or nearly so which decreases the producing capacity of the plant. On this account up-to-date planters have generally adopted a system of pruning by which the coffee trees are headed low, giving a maximum yield coupled with easy access to the berries.

The pruning consists of topping the robusta trees when they are from 2 to 2.5 meters tall and of subsequent pruning to keep

the trees at this height. This work should preferably be done while the plants are of the proper height and the green shoots easily broken off, and not after the trees have exceeded the height limit by several decimeters. The plant, if allowed to do so, usually sends up a large number of suckers from the base, which constitute a drain on the vitality of the plant. Therefore, all superfluous suckers should be removed and not more than 2 to 3 stems to a plant should be permitted to develop.

Occasionally robusta plants appear that are more than ordinarily subject to blight, and these should be at once pulled up and burned.

Yield.—The yield of robusta coffee is quite variable, much depending upon the fertility of the soil. On the more fertile soils in Java the yield per hectare in the third year was approximately 540 kilograms, and in the fourth and fifth years, 1,400 and 1,830 kilograms, respectively. In old coffee or cacao fields the yields were 325, 540 and 850 kilograms per hectare, respectively, during the third, fourth, and fifth years after planting. It is perhaps well to recall the fact that the average yield of Arabian coffee in the Philippines is 174 kilograms per hectare, which is of course much less than it should be, and *it is not believed that the Philippine planter with his present methods of cultivation could equal with robusta coffee the yields quoted from Java.*

The immense superiority of the robusta as a cropper over the ordinary Arabian coffee is best illustrated in a table published by the Department of Agriculture, Java. We learn here that in Java, under identical conditions, the yield per plant was of Arabian coffee, 53 to 97 grams; of robusta, 992 grams; and of quilloi (a new very rare coffee) 1,020 grams. The Maragogipe hybrid on its own roots yielded 14 to 18 grams, while grafted on robusta the yield was 156 grams, a larger crop than any Arabian coffee has given in Java. This would tend to show the possibilities of robusta as a stock. Further, comparative studies by Cramer have shown that 4 to 5 kilograms of fresh robusta berries make 1 kilogram of coffee while of the Arabian coffee 5 to 6 kilograms of fruit are required to make 1 kilogram of coffee.

Owing to the fact that the pulp on the robusta coffee (though smaller in amount) is more difficult to remove than that on the Arabian, robusta needs at least two and one-half days of fermentation. The bean requires rapid drying in order to loosen the silver skin and the drying is therefore done in an artificially heated shed.

Quality and marketability.—Relative to the quality of the robusta coffee Doctor Hall says:

> The appearance of the average marketable robusta is not very beautiful; the beans are small and irregular, and the average product shows little uniformity. There are, however, great differences between the many different types of robusta. Some of them have comparatively large beans, larger even than arabica, others again have very small ones. As regards the quality, though being inferior to Java-arabica, the taste is generally considered to be good and superior to the ordinary arabica sorts, as Santos.

Doctor Wildeman states:

> It is objected that the berries of the robusta group and of other African coffees are small in size and inferior in flavor; but the continually increasing quantities of these coffees sold in Holland, and the satisfactory prices they fetch show that the public is beginning to appreciate them. No objections will be made to the size of the berries when by means of careful cultivation and especially of right preparation, a coffee is obtained equal in flavor to the (old) Java and Arabian coffee.

SUMMARY.

Arabian coffee cannot be successfully grown in the Philippines below an altitude of 800 meters, and even at this elevation, due to its susceptibility to the coffee blight, extensive planting of Arabian coffee cannot be recommended.

Success with Arabian coffee is obtainable only by keeping the plantations clean of weeds and the plants in the best possible condition.

For the rehabilitation of the Philippine coffee industry robusta coffee appears more promising at present than any other kind.

The advantages of robusta coffee are that it thrives under more varied conditions than Arabian coffee, that it is an earlier and a more prolific bearer and that it is resistant to the blight.

Blight resistance in robusta coffee does not mean that it is *immune,* but that *notwithstanding the presence of the blight it grows well and produces abundant crops.*

Robusta coffee is by some authorities regarded as inferior in quality to Arabian coffee. Nevertheless, considering the optimism with which robusta coffee is regarded by conservative European experts in tropical crops, coupled with the results obtained in Java, it is confidently believed that robusta coffee is worthy of extended planting in the Philippines.

From the Dutch department of agriculture in Java the Bureau of Agriculture has imported seed of the best robusta coffee available for distribution, as well as a considerable quantity of seed of the ordinary robusta cultivated in that island. All readers who are interested in planting robusta coffee are cordially invited to communicate with the Bureau of Agriculture.

CANE-JUICE CLARIFICATION.

By Cleve. W. Hines, M. S., *Station Superintendent.*

The clarification of the juice forms one of the most important operations in sugar manufacture, since the higher the purity of the juice to be concentrated, the greater the percentage of sucrose that will crystallize, and the easier it will be to make a marketable sugar. If a high-grade sugar, or even yellow clarified sugar is to be made, this work should receive still greater attention.

Before considering the methods to pursue and the reagents to use, it is well to decide first upon the grade of sugar it is desirable to make. If ordinary centrifugal sugar testing 96° is desired, it will usually be practical to use only lime in the clarification, since in these Islands cane reaches full maturity, and consequently the purity of the normal juice will be quite high, sometimes as high as 90° or 92° (apparent purity). If, however, it is desired to make a white plantation sugar, or granulated sugar, it will be advisable to subject the juice to an acidifying or bleaching treatment, as well as to the lime treatment. Usualy sulphurous acid is used for this purpose, but sometimes phosphoric acid, or a form of it, is employed. It is generally best to administer the acidifying agent before the application of the lime, since this raises the acidity and permits a larger amount of the lime to be used. However, this process is reversed by some manufacturers, and very good results are often reported.

In the acidifying of any cane juice, care must be exercised that too high an acidity is not reached, since acids have an inverting effect upon sucrose, thus causing a noticeable loss. This of course depends upon the degree of acidity carried, the temperature maintained, and the methods followed during the time the juice remains acid.

When it is desired to make a high-grade crystal for granulated sugar, the clarification must be more complete, and a water-white thick liquor should result, without subsequent treatment by bleaching agents and other chemicals, except the neutralizing of the slightly yellowish tint, which will be mentioned later.

REAGENTS USED IN CLARIFICATION.

There is a great variety of reagents at the command of the sugar manufacturer, each of which has certain merits over others, and all are valuable in their place when properly used. It will therefore be the duty of the operator to select those which best meet his individual conditions.

It is the purpose of this article to give a brief survey of the more common reagents which, under certain conditions, may be used to advantage in these Islands.

Lime.—This is perhaps one of the most common and most widely used of all the reagents. Since the object in view is to increase the purity of the juice, it is obvious that the purest rock obtainable should be used in the preparation of the lime. Another reason why a good lime should be employed, is that one of the main impurities of the lime rock is magnesium, which, when mixed with cane juice, becomes very troublesome in the incrusting of the evaporator tubes, thus greatly lowering the coefficient of heat transmission.

Much of the lime on the market in the Philippines has been made without any attempt to select pure clean limestone or shells. This is not suitable for putting into cane juice, and will result in a great deal of trouble whenever used in modern evaporating plants. There is, however, an abundant supply of limestone found in various parts of the Philippines, which analyses show to be almost free from impurities, and which will make a most excellent lime for clarifying purposes if burned properly. At present there is no modern plant for burning this rock on a large scale and consequently much of the work is done in a very crude and unsatisfactory manner. Most of the lime for clarification, in modern sugar factories, is imported, and constitutes a very heavy expense. If a lime kiln were installed in conjunction with some of our sugar factories, fresh and well-burned lime might be made as needed. The carbon dioxide could be used in the juice clarification, as is done in Java, and thus a good grade of plantation sugar could easily be manufactured. Any excess of burned lime might very readily be sold to other factories, which now use only high-priced imported lime.

The lime used should be of the unslaked type, and should be protected from the air until a short time before using. The process of preparing this consists of heating lime rock to a very high temperature, in a kiln for that purpose, whereby the limestone is broken into two component parts, expressed by the following chemical equation: $CaCO_3$ (limestone) heated to high temperature $\rightarrow$CaO (calcium oxide) + CO_2 (carbon dioxide).

This calcium oxide, commonly known as "quick lime," is the substance desired in clarification. It should be slaked by being placed in water just before it is desired for use. This milk of lime should not be used until after the high temperature caused by the violent chemical action has subsided. On account of the heat involved and the high alkalinity in local portions, it is never safe to apply crude lime to the juice without previously slaking it in water, nor is it advisable to use a quantity of juice to mix this lime, as is quite often practiced in these Islands, since in this case there may be a loss of sucrose, with a resulting dark-colored product, which will impair the color of the clarified juice. The following chemical equation will express the reaction when this lime is slaked: CaO (calcium oxide) + H_2O (water) $\rightarrow$Ca(OH)^2 (calcium hydroxide).

This calcium hydroxide is a substance which is very caustic, and care must be exercised in handling it. Like all bases, it has a great affinity for acid, and consequently its first action is to neutralize part of the acids present. It then coagulates albumins and albuminoids, which form a part of the impurities, and throws down insoluble salts of sulphates, carbonates and phosphates, and of the bases iron and aluminum. These act as mechanical precipitants, assisting in bringing down other impurities. The compounds of calcium are practically insoluble in cold cane juices, and may be readily filtered, or settled, and the supernatant liquor drawn off. In the addition of lime, as well as in the application of other reagents, much care must be observed that the proper amount is added. If too little is used, there will be poor clarification and settling of the precipitate, while if too much is used, so that alkalinity is reached, and the juice heated to a high temperature, there will be a darkening of the juice caused by the decomposition of the reducing sugars by the calcium, and the formation of dark-colored compounds, which are very hard to remove. If the juice is limed to three-tenths or four-tenths cubic centimeter acidity against N/10 NaOH, using phenolphthalum as an indicator, there will be little or no chance of trouble. With the above dangers in view, it is not safe to employ the haphazard methods of liming usually practiced here, but the milk of lime should always be made of stated density and a measured or weighed amount should be supplied to each clarifier of juice, corresponding to prevailing conditions.

Sulphur dioxide.—Where a better grade of sugar than 96° test is desired, it is often advisable to subject the juice to further treatment, one reason for which is to increase the acidity so that a larger amount of lime may be added to effect the clari-

fication. In addition to this the sulphur acts to some extent directly as a clarifying agent, by precipitating some of the impurities. It also acts as a bleaching agent by extracting the oxygen from the impurities and lastly it acts as a disinfectant. It is formed by burning crude sulphur in a stove made for that purpose. S (sulphur) + O (oxygen heat) $\rightarrow SO_2$ (sulphur dioxide).

Sometimes bombs filled with liquid sulphur dioxide are purchased for this purpose. These are inconvenient to use, and this method is ordinarily more expensive than the usual one of burning the sulphur and producing the gas directly at the factory.

Sulphur dioxide is a heavy gas which is very readily absorbed in water, and at a temperature of zero C. nearly 80 per cent by volume of the gas will be taken up.

At 40° C. only about 18 per cent by volume of the gas will be absorbed. It may readily be seen that the percentage of gas contained in the juice when saturated will be determined by the temperature.

The following equation expresses the absortion of sulphur dioxide in water at ordinary temperature:

SO_2 (sulphur dioxide) + H_2O (water at low temperature) $\rightarrow H_2SO_3$ (sulphurous acid).

Another thing of very great importance is the cooling of the gases to condense any water that may be present so that no hot gas will reach the juice to be treated or combine with water in the pipes. The equation represented when high temperatures are used is as follows:

SO_2 (sulphur dioxide) + H_2O (water) + O (high temperature) $\rightarrow H_2SO_4$ (sulphuric acid).

This last-named acid is very corrosive and a powerful investing agent. It therefore has the property of rapidly destroying sucrose, especially at a high temperature.

In the burning of sulphur it is well that as thorough a combination as possible be obtained, else there will be a loss of sulphur, which will deposit in the tubes and choke them, and more time will be required for the process. The fumes from a well-regulated sulphur furnace should contain from 15 to 16 per cent sulphurous acid. The theoretical percentage obtainable is about 21 per cent of the acid.

Carbon dioxide.—In recent years carbon dioxide gas has found a very useful application in the cane-sugar factories, where a good grade of plantation sugar is desired.

Java factories have been the foremost in elaborating a system, through their eminent technologists, so that today one may find the bulk of the sugars they turn out from certain factories

of a very satisfactory grade and color. The method they use requires a great deal of skill and attention in order to yield results that are satisfactory. It is patterned after the process used in beet-sugar factories, with some distinct modifications, which make it applicable to a juice containing glucose, as is always the case with cane juices.

The object of applying any clarifying material is to effect a rise in purity, and it is especially desirable to remove, in all cases, the substance added, since this itself would tend to act as an impurity and thus give a lower coefficient, if not properly removed. The lime, which has been added previously, may be partly removed, as the original precipitate formed, and any free lime or compound which may be easily decomposed will combine with carbon dioxide, forming calcium carbonate or limestone, which is quite insoluble and may be very easily filtered off.

$Ca(OH)^2$ (calcium hydroxide) $+CO_2 \rightarrow CaCO_3$ (calcium carbonate) $+H_2O$ (water).

Whether single or double carbonation is used, the same general methods are employed, and results are expressed by the same chemical equation.

As stated before, the carbon dioxide may be recovered from the kilns during the burning of lime, as is commonly done in the beet-sugar industry, or it may be purchased in the form of liquid CO_2 contained in heavy iron containers. It is also feasible to use flue gases for this purpose, where a good combustion is obtained, and after they have been properly treated.

Phosphoric acid.—It is sometimes advisable to apply a form of phosphoric acid as a clarifying and precipitating agent after the lime. This may be used in various forms depending upon the individual desires of the operator.

The compound usually found on the market may consist of one of the following (or a combination of them):

H_3PO_4 (ortho phosphoric acid).

$CaH_4(PO_4)^2$ (mono-calcium phosphate).

$Ca_2H_2(PO_4)^2$ dicalcium phosphate).

Na_2HPO_4 (sodium phosphate).

The sodium phosphate contains very little acidity, and the main purpose of its use is based on the principle that the sodium is readily given up for any soluble calcium that may be present. This forms the insoluble calcium phosphate, which is easily removed as a precipitate or filtered off. The "Reserve Factory" in Louisiana has been using this reagent in their clarification for a long time, where a very good grade of granulated sugar is made.

Besides these forms of phosphorous, various compounds may

be found on the market, under trade names, which have as their base the above acid. "Clariphos" is one of these compounds, which has found extensive use in many of the Louisiana sugar factories.

Another is known as "phospho-gelose," which is a combination of dicalcium phosphate $Ca_2H_2(PO_4)_2$ and infusorial silica. It is a patented preparation and is made by the absorption of phosphoric acid by a powdery compound known as "Kieselguhr." After the absorption, the compound is heated to expel the water, and then resaturated. This work is repeated several times until the finished product, which is very hydroscopic, contains about 25 per cent of phosphoric acid.

Kieselguhr.—This is a fine light powder containing a high percentage of silica. It is used purely for its mechanical effect in forming particles upon which the impurities may collect, and thus be more readily carried to the bottom. This material often prolongs the workings of the filter presses by collecting the gummy material, which would otherwise gather on the filter cloths. Kieselguhr was used in the beet-sugar industry of Europe many years ago, and is extensively used now for the same purpose in the United States.

Hydrosulphites.—These are preparations of great bleaching power, found on the market under various trade names. One of these, widely used in the United States, in both the beet and cane-sugar industries, is known as "Blankit." This is dehydrated sodium hydrosulphite with the chemical formula, $Na_2S_2O_4$. It has a much greater bleaching and reducing action than sulphurous acid, and oxydizes very readily in combination with moisture, forming sulphate. On this account it is well to purchase the reagent in small parcels for this climate, and to carefully guard the stored material from moisture. This substance, which is a white powder, dissolves very easily in water, forming an alkaline liquid, although this point is sometimes hard to distinguish on account of hydrogen atoms liberated.

There is a bleaching preparation made in France known as "Redo," which is simply calcium hydrosulphite (CaS_2O_4). This is used in the sugar industry to some extent, but it is claimed by many that the results obtained are not as good as those obtained from the sodium compound and that it deteriorates more easily.

Hydrosulphites, unlike sulphurous acid, will bleach equally as well in alkaline or neutral medium, as in an acid medium. There is therefore less danger from loss of sugar by inversion when they are used, while the permanency of their effect is about the same. In any case where juices have been bleached

by sulphites, the result may be considered as but temporary, since upon exposure to air and light the product assumes a darker color. Hydrosulphites should therefore be introduced as late in the process as possible. Where the material in the vacuum pan is to be bleached, it is well to introduce this reagent just before striking grain, thus furnishing a bright clear material which will act as film over the nucleous of sucrose in the grain.

The chemical equation representing the change which takes place with this reagent is as follows:

$Na_2 S_2O_4$ (sodium hydrosulphite) + O (oxygen) + H_2O (water) $\rightarrow 2(Na\ H\ S\ O_3)$.

The amount to be used will depend absolutely upon individual conditions, which may be ascertained only by experimentation. The manufacturers of this product state that the amount of the material used to that of dry sugar should be as 1 is to 10,000. In the writer's experience, two or even three times this amount will usually be required to give maximum results. As stated before, since there is such a variance in the material to be treated, each operator will be required to judge this to a great extent from the condition of his product.

In these Islands where a very low grade of open-kettle sugar is still made, which sells very cheaply, attempts are often made to bleach it and recrystalize in order to make a centrifugal sugar.

While ordinary clarifying agents help to a great extent, if the melted sugars are very dark from caramel and the decomposition products of calcium glucosate, these reagents can not be expected to give a light-colored juice. While they may improve conditions somewhat, the only solution to such a problem is the use of the boneblack process.

Bluing.—In the production of plantation clarified sugars, and sometimes of refinery crystals made from low-grade sugars, there is a thin film surrounding each sugar crystal, which has a yellowish tint. It is this that gives rise to the different grades of white sugars, when color test only is considered. Since this yellowish tinge will give way to a lighter color when neutralized with the proper shade of blue, it is a very common practice to use some form of bluing—usually that known as ultramarine—for this purpose.

The action of this reagent is only mechanical and great care must be exercised that the proper quantity is used. This must be determined by trials with the different amounts of the reagent, since the density of the yellowish tint is different in each case.

The place of application will also depend very much upon con-

ditions. Some operators apply it only at the centrifugals and others apply it in the pan just at the graining point. Again others use a quantity at both the pan and in the last charge of water at the centrifugals. In any case, a good grade only of the reagent should be used. This must be thoroughly dissolved in clear water, condensed steam being preferred, and passed through cloth or felt filters in order to remove any trace of lumps which would tend to produce uneven bluing, or bluish streaks.

While this is an excellent reagent in its place, it must not be expected to whiten molasses sugars as was attempted by a local manufacturer.

Animal charcoal or boneblack.—This material is made from bones of animals, by burning them in a kiln built for that purpose. The object of this burning is to remove the organic matter and leave the remainder in a porous condition, so that it may be crushed into particles the proper size. It is not desirable to have a great amount of char dust present, since this retards the passage of the liquors through the filters, as well as impairing the efficiency of the work.

Bone char, being very porous, absorbs a great volume of gases, among which is oxygen, and it is ordinarily presumed that its bleaching power may be attributed to this fact. Extensive experiments have been made to determine definitely this point, and the char has been subjected to an atmosphere of other gases than oxygen. This proved that the char still contained great clarifying power.

Char also has a great surface attraction, which causes it to collect particles of coloring matter that may be present, and thus acts as an excellent filtering agent. New char should be thoroughly washed with pure water until all the impurities are removed. With the end in view of determining when the last traces of chlorine have disappeared, chemical tests are made on the wash waters. Nitric acid and silver nitrate are employed for this purpose. After animal char has been used for some time in the filters and fails to do its work efficiently, it is reburned, or revived, as it is called. Ordinarily the best results are obtained after a char has been used several times.

Reburning of the char at too high a temperature should be avoided, as it incurs an unnecessary loss of fuel, besides causing serious injury to the char by a contraction of the pores. Since, as stated previously, the main value of the char as a clarifying and filtering medium lies in the fact of its porosity, anything which reduces this will greatly impair its efficiency. One thing in connection with the bone-char process of making white sugars

is that it is expensive and should not be attempted except on a large scale, since the initial expense of installation, as well as the cost of running, is very great. The writer is sometimes asked by managers of small factories, turning out plantation yellow clarified sugars, if it would not pay them to employ bone-char filters to use in connection with the remainder of their factory, in order to be able to work up an industry with the low-grade open-kettle sugars, during the intercampaign. Most assuredly such a combination of small plantation factory and refinery would not be a paying affair. It takes men of experience and special training to carry out successfully the more detailed work in any technical line. One thing, however, can be very successfully done by these factories, and that is to make a first-class plantation white sugar which will command a ready price in the local markets, or even suffice for export, if the proper manufacturing methods are used.

It is not presumed that any one planter will use all of the clarifying reagents mentioned above, but he should choose the ones to fit his individual needs, and secure his supply early, since a great deal of time is required to transport supplies from the place of manufacture to these Islands. This is especially the case when the place of manufacture happens to be in Europe, as is true with a number of the patented clarifying reagents.

Then, again, a suitable place should be selected for the storage of reagents, where they may be protected from dampness. The quick-lime and sulphites are especially susceptible to moisture, while the greatest danger of loss, when phosphoric acid compounds are stored, will result from leakage. This is on account of the great oxydizing effect of the acid on the iron loops surrounding the barrels, whereby a great quantity may be lost within a very short time. The writer observed this needless waste in one of the small factories here, when twenty barrels of a high-priced acid were stored on the damp ground of the factory, and a great percentage of it wasted.

There are a number of clarifying agents offered on the market under fancy names. Planters are advised to be cautious about the purchasing of such supplies until they have been thoroughly tried out and proven a success. Even then, it is better to experiment only on a small scale until it is known that they will meet their individual needs.

Some of these are not only deficient in clarifying power, but actually act as an absolute detriment by introducing impurities which lower the value of the juice as well as increasing the subsequent work of boiling and after working of the sugar.

LA FABRICACION DE AZUCAR BLANCO EN LOS INGENIOS.

By W. H. Th. Harloff and H. Schmidt.
Translated into Spanish by C. J. Bourbakis.
(Reviewed by Cleve. W. Hines, M. S., *Station Superintendent.*)

This book is edited by two of the foremost sugar producers of the world, Mr. Harloff, who is manager of a large sugar factory in Java, and Mr. Schmidt, a very able consulting chemist and engineer.

The book was originally written in Dutch and was translated into English, and now the Spanish edition has been completed, which will be welcomed by Spanish readers throughout the sugar world.

While dealing with a purely technical subject, this work is so simple in its diction that it may be readily comprehended even by those of little technical training.

The introduction is divided into five parts as follows:

Part I.—The influence of alkalies and alkaline earths on the constituents of cane juice.

Mention is here made of the formation of saccharates of barium, strontium, and calcium in low concentrations. The latter is made use of in the famous Steffens process of the beet-sugar industry.

Part II.—The influence of acids on the constituents of sugar cane and the hydrolizing effect of dilute acids on sucrose and the resulting constituents, laevulose and dextrose or invert sugar, are explained.

Part III.—The influence of heating on the constituents of cane juice is shown.

Part IV.—The coloring substances of cane and those produced in the process of manufacture.

Part V.—The different fermentations that occur in the sugar factory including lactic, butyric, alcoholic and dextran are discussed.

The main part of the text deals with the manufacture of white sugar by the carbonitation and sulphitation processes, and particular attention is given to the acid-thin-juice-method which has been elaborated in the Java factories with such great success during the past few years.

This book may be obtained from Norman Roger, 2 St. Dunstan's Hill, London, England. Price 7s. 6d. net (₱4 Philippine currency).

CURRENT NOTES—FIRST QUARTER.

NOTES BY P. J. WESTER, Horticulturist in Charge of Lamao Experiment Station.

SHIELD BUDDING THE MANGO.

The one defect in the Pound method of shield budding the mango described in Bureau of Agriculture Bulletin No. 18, The Mango, consists of the necessity of placing an apron to protect the long petiole left on the bud from the sun and the entrance of water, which work necessarily requires more time than if the bud could be wrapped as is the case in budding citrus trees. However, a possible use of scarred or nonpetioled budwood as a means of obviating the need of the apron was suggested in the above-mentioned publication. The results obtained in recent experiments conducted at the Lamao experiment station (November and December, 1914) have fully come up to the expectations of this modification, and if the work is carefully performed, the operator should have no trouble in obtaining 85 per cent of live buds by proceeding in accordance with the following directions:

(1) Select budwood that is well matured, from the first, second, and third flushes from the end of a branch. This budwood is always green and smooth.

(2) Three weeks or more in advance of the date when the budding is to be performed, cut off the leaf blades of the budwood selected. This causes the petioles to drop. When the scars left after the petioles have fallen are well healed the budwood is in condition for budding.

(3) The buds should be cut about 4 centimeters long, with an ample wood shield, and inserted in the stock at a point where the bark is green and smooth like the budwood, not where it is rough and brownish.

(4) Use waxed tape in tying and cover the entire bud.

(5) When in the course of two to three weeks a good union has formed, unwind the wrapping so as to expose the leaf bud from which the growth is to issue, and cut off the top of the stock 10 to 15 centimeters above the bud.

(6) Every ten days after unwrapping the buds go through the nursery and carefully rub off all stock sprouts in order to force the buds to grow.

All other precautions that are taken in ordinary shield budding must, of course, also be attended to in order to insure success.

EXPERIMENTS IN SHIELD BUDDING.

After repeated attempts the shield-budding experiments at the Lamao experiment station with the camia (*Averrhoa Bilimbi*) and the santol (*Sandoricum koetjape*) have been successful, and it has also been found that the barobo (*Diplodiscus paniculatus*), a nut tree indigenous to the Philippines (*Dillenia indica*), and the sea grape (*Coccoloba uvifera*), may be propagated by means of shield budding. Detailed information relative to the budding of these plants will be published on the completion of the experiments.

IMPROVEMENT OF TROPICAL FRUITS IN THE PHILIPPINES.

The average fruit is so poor that most foreigners never give any attention to the santol, and the fruit is a drug even in the native markets and enormous quantities annually rot on the ground. Few are aware that there are mutations among the santol trees the fruit of which in point of flavor vies with the best fruits in the Tropics, and that in this respect it is superior even to its celebrated relative, the lanzon (*Lansium domesticum*), the greatest defects being the large seeds and the adherence of the flesh to the seeds. If the seed in these superior santols were abortive in the same proportion as those in the mangosteen, the now despised santol, with its translucent pulp, separable from the pericarp as that of the mangosteen, subacid, juicy and of a vinous, excellent flavor, would rapidly become one of the most popular fruits in the Tropics. Its thick, tough "rind" should make the santol at least equal to the mangosteen as a shipper.

What is probably the first horticultural, asexually propagated variety of the santol is now being established at the Lamao experiment station from buds obtained by Mr. F. Galang, assistant agricultural inspector, from a tree in Pampanga, the fruit of which is so highly prized locally that the fruit never retails below the relatively high price of 2 centavos apiece even when other santols are so plentiful as to be literally unsalable.

Mr. B. Malvar, assistant agricultural inspector, has obtained in Batangas budwood of a sweet-fruited camia which is also being propagated. This is the first mutation of this kind coming to the attention of the writer.

The collection of Philippine citrus fruits of economic value or of botanical interest has been in progress since in 1911, but no systematized selection work in the mandarin district has been attempted until December, 1914, when Mr. B. Malvar was detailed to visit the citrus region in Batangas. Mr. Malvar re-

turned with sample fruits of some twenty odd trees, a number of which were found to be of very good quality. These are being propagated for future distribution. Mr. Malvar also found another "Tizon" (*Citrus nobilis* var. *papillaris*) of excellent flavor and quality which has been added to the citrus collection at Lamao.

PETIOLED VS. NONPETIOLED BUDWOOD.

The last three years' experiments in shield budding tropical fruits which have been conducted by the writer at the Lamao experiment station indicate that for practical purposes in propagation work the tropical fruits may be divided into two groups: (1) Those species the budwood of which may be cut at the time of budding and the petioles cut off close to the bud—for instance, the citrus fruits, avocado, guava, and carambola; and (2) those species in which decay enters the bud from the adhering remnant of the petiole so frequently as to make impracticable budding from newly cut budwood from twigs with the leaves still adhering, such as the mango, hevi, and cacao. It has been found, however, that this trouble may be easily overcome by the simple method of cutting off the leaf blade about three weeks in advance of when the budding is to be done so as to induce the formation of a leaf scar. Then when the petioles have dropped and a well-healed scar has formed, the budwood may be cut and the buds inserted and tied as in ordinary shield budding.

In the case of some species, whether or not the bud is of the same age as the stock at the point of insertion is of little or no practical importance, but in other species this condition is one of the requirements for success. Therefore, two chances of failure are insured against in experimental work with species that hitherto have not been budded—(*a*) by defoliating the budwood previously to the budding operation, and using what may be termed nonpetioled or scarred budwood; and (*b*) by inserting the buds at a point in the stock which approximately is of the same age and appearance as the budwood.

NOTES BY CLEVE. W. HINES, M. S., *Station Superintendent.*

A NEW SUGAR INDUSTRY.

The beginning of a tropical industry in what would be considered a semitropical climate was noted in 1914, when the Southwestern Sugar Company of Arizona milled their first crop of sugar cane and made it into sugar. The factory had been used previously for the manufacture of beet sugar only. It is a

singular coincidence to find a region where both cane and beets will thrive well and where sugar is made from both sources in the same factory, and the sugar world is looking forward with great interest to the results of this new venture.

THE WORLD'S SUGAR SUPPLY.

The world's production of sugar amounts to nearly seventeen million tons, practically one half of which is derived from the beet root, the greater percentage of which is produced in Europe. Now that the ravages of war have devastated many of the better beet-sugar regions of Europe a greater demand will be made on the more fortunate sugar countries as soon as the present supply of storage sugar is exhausted and trade resumes its normal condition.

PROGRESS IN SUGAR MANUFACTURE.

The past few years have shown great progress in the method of sugar making. It used to be thought that a high grade of sugar could be made only by the use of the bone-black or animal-char process.

The beet-sugar producers were the first to diverge from this method and succeeded in making a perfectly satisfactory sugar in their factories in one continuous process by the aid of the carbonitation system.

Louisiana had been making a fairly good sugar known as yellow clarified for a number of years, but the great step in improvements along these lines was brought about by the acid-thin-juice process of Java. This was a combination of the carbonitation and sulphitation processes which gave a satisfactory sugar, though unfortunately the yield of resulting molasses was also quite high.

The latest improvement in this work was the introduction of the "Battille Process" which has certain similarities to the Steffens process of beet-sugar manufacture. This method has given an excellent grade of sugar and the maximum rendement since practically all of the sugar is extracted in crystalized form.



(*a*) Office building, Lamao Experiment Station, 1914.



(*b*) Residence of superintendent, Lamao Experiment Station, 1914.

THE PHILIPPINE

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EDITORIAL.

THE FARMER'S PROFESSIONAL STATUS.

Agriculture was one of the first professions which man adopted in his evolution from primitive or elemental conditions to those more modern or complex.

As he began to cultivate the soil, to plant seeds and to harvest crops, he met problems to be solved, and, groping about for a solution of these, he quite by accident discovered that certain causes produced given effects.

Thus, we note that for ages the agriculturist has practiced plowing the soil, though unable to give good reasons for so doing. Even to this day, in the older communities, one hears a certain practice defended on the score that it is customary; it is, in other words, sanctified by virtue of tradition.

When the attempt was made to cause the farmer or agriculturist to introduce science in his work, the struggle was quite severe.

On one hand was the farmer's aversion to change, his sense of independence being touched, and it was his opinion that the public and the government should mind their own business. On the other hand, the public upbraided the government for not doing more for the farmer and often insisted that its officials and institutions should place themselves on the same intellectual level as the farmer.

Science is knowledge of principles or facts, or, in other words, systematized knowledge.

How can an institution which owes its existence to systematized knowledge place itself on the basis of conjecture, superstition and tradition?

Some of us can recall hearing many scathing criticisms of "book farming" methods, and sarcastic remarks directed at the state agricultural institutions and the federal department of agriculture.

Twenty-five years ago agriculture as a scientific profession had but little systematized knowledge as a basis and farming then was carried on along lines largely traditional.

During the last twenty-five years tremendous advances have been made in agricultural science; in fact, the advance has been so rapid that the layman does not realize the changes which have occurred. Meanwhile, a metamorphosis of the agriculturist has taken place. He has seen the advantage of better general education, has availed himself of his opportunities and has secured better facilities for the education of his children. With this gain in general education has come appreciation of specialized training, which has resulted in the establishment of agricultural schools. The spirit of progress has made him a student and a reader, and, to gratify this desire for up-to-date information relating to his profession, several thousand agricultural publications have sprung into existence.

The agricultural scientist has not descended to the farmer's level but the farmer has ascended towards the scientist's level.

Today the world realizes, at least in a measure, that agriculture is a scientific profession; then, should it not also grant the presumption that those who follow this profession are capable of comprehending its language?

In discussing the farmer it would be well for the public at large to educate itself to a better comprehension of his dignity and economic importance, and to appreciate the marked advancement he has already made.

THE LAMAO EXPERIMENT STATION.[1]

By P. J. WESTER, *Horticulturist in Charge.*

The Lamao forest reserve, containing about 4,426 hectares, located 7.5 kilometers south of Limay, Province of Bataan, was established by proclamation of the Governor-General July 26, 1904. The present experiment station, situated on the reserve and having a fenced area of approximately 40 hectares, of which about 15 to 18 are under cultivation, is exceptionally well located both from an esthetic and a practical point of view, its chief drawback being isolation from any trade route.

Owing to the peculiar formation of the land, the station enjoys many natural advantages that are seldom combined. Its location is unusually attractive, the experimental fields being well sheltered by forested hills and individually separated by small creeks along which grow luxuriant bamboo, forming admirable natural windbreaks. During the rainy season the creeks carry off the surface water and during the dry season they absorb the surplus water in the course of irrigation. The gentle slope of the fields from west to east facilitates irrigation, for which a superabundance of water is obtained at a slight expense from an arm of the Lamao River which skirts the station on the south.

The soil is a clayey loam of average fertility with varying admixture of sand. Practically all the land must be carefully watched relative to cultivation after irrigation, for if plowing or cultivation is performed either when the soil is too wet or too dry, it breaks up into large, hard clods. With the continued plowing-under of green-manure crops this defect will disappear in time.

No records are now available of the precipitation at Lamao previous to 1913. The total rainfall during 1914 was 3,207 millimeters, falling principally from June to October, thus necessitating irrigation during the larger part of the year. While there is some variance in the precipitation, this may be considered as typical.

[1] For an earlier account of the Lamao Experiment Station see this REVIEW, Vol. III (1910), No. 10, page 581.

The site of the Lamao Experiment Station was selected by Major Geo. P. Ahern, recent Director of Forestry, and ground was first broken in August, 1903. The Bureau of Forestry established three stations: station No. 1, which is the present experiment station, fronting on Manila Bay; station No. 2, approximately 4 kilometers from the bay at an elevation of 60 meters; and station No. 3, about 17 kilometers inland and 600 meters above sea-level.

November 10, 1905, the Lamao station was transferred from the Bureau of Forestry to the Bureau of Agriculture and Mr. Harold Cuzner was appointed superintendent. Mr. Cuzner was succeeded in January, 1908, by Mr. H. E. Stevens who continued in charge until February, 1909; he was followed by Mr. O. B. Burrell who remained at Lamao until March, 1912. Mr. F. C. Kingman then superintended the station until December, 1912, when the writer was placed in charge.

At present the station staff includes the horticulturist in charge, the superintendent—Mr. H. C. McNamara, three agricultural inspectors—Mr. Mariano Manas y Cruz, Mr. Francisco Galang and Mr. Bernabe Malvar, one farm foreman, and one plant propagator. From 8 to 25 day-laborers are employed occording to need.

When the station was under the control of the Bureau of Forestry it was operated as a forest nursery and for the propagation of numerous economic and decorative plants which were grown or imported by the Bureau. Some of the more prominent importations made by the Bureau of Forestry included avocados and bananas from Hawaii, papayas from India and pineapples from Ceylon. Deciduous fruit trees were also imported, as well as California oranges and lemons, and 500 coffee trees of various varieties from Java and India. These plants were all planted at the 2nd and 3rd stations. Later, in 1906, when these two stations were abandoned, the living plant material was transferred to the site of the present experiment station.

Having been principally a forest nursery while under the Bureau of Forestry, the station after its transfer to the Bureau of Agriculture up to 1912 was chiefly devoted to horticultural work, the remaining areas being planted to fiber, forage plants and rice. Up to 1911 much time was necessarily occupied in clearing and stumping the land.

Briefly mentioned, the principal plant work up to 1913 was as follows: 4 hectares were planted to sisal and Philippine maguey in 1906; in 1907 there were planted about 200 liberian coffee plants, 48 varieties of grapes, 1.5 hectares of abaca, 1

hectare of bananas including 6 varieties, a small test orchard of guavas and the following tropical fruits: chico, *Achras sapota;* pitanga, *Eugenia uniflora;* genipap, *Genipa americana;* custard-apple, *Annona reticulata;* jak, *Artocarpus integrifolia; Flacourtia cataphracta;* macadamia, *Macadamia ternifolia;* loquat, *Eriobotrya japonica;* kayam, *Inocarpus edulis;* caymito, *Chrysophyllum cainito;* and bael, *Aegle marmelos.* In 1908 there were set out a number of Queen pineapples, an avocado orchard and 0.5 hectare of mulberries. In 1909, 0.25 hectare was planted to kapok and 0.25 hectare to abaca, and also about 50 achuete, *Bixa orellana,* some 300 papayas, 200 robusta coffee plants and a few cacao plants were set out. In 1910 the following tropical fruits were planted: yambo, *Eugenia jambos;* duhat, *E. jambolana;* soursop, *Annona muricata;* breadfruit, *Artocarpus communis* (seedy variety); carambola, *Averrhoa carambola;* mabolo, *Diospyros discolor* (2 varieties); zapote negro, *D. ebenaster;* pulasan, *Euphoria mutabile;* rambutan, *Nephelium lappaceum;* santol, *Sandoricum koetjape;* date, *Phoenix dactylifera;* pomegranate, *Punica granatum;* barobo, *Diplodiscus paniculatus;* tamarind, *Tamarindus* indica; and the following citrus fruits imported from Australia: Oranges—Washington Navel, Navelencia, Bahia, and Mediterranean; Lemons—Belair, Lisbon and Villafranca; also some 500 orange and cabuyao stocks were propagated.

Of the above-mentioned plants both plantings of abacá died because of uncongeniality of climate; all the plants of the tropical and citrus fruits enumerated were in good condition when the writer first saw the station in March, 1911, and are still growing. The growth of both species of coffee was satisfactory and up to date none of the plants has been attacked by blight (*Hemileia vastatrix*). The avocado orchard still remains, though many trees have succumbed to attacks of borers. After testing the fruit of the individual seedlings, about 80 per cent of the guava plants were destroyed by the writer in 1913, leaving the best trees for further testing and breeding work. The cacao died while the plants were small, owing to uncongenial climatic conditions. Most of the bananas were destroyed in 1912 because of the appearance of budrot and a few plants were transferred to another field. The maguey plants and mulberries did very well and yielded very large amounts of plant material for distribution. The kapok and achuete, *Bixa orellana,* plantings were uprooted in 1912 as of no further value. The grapes all died without making any growth worth mention. Rubber plants and various other tropical economics were planted from time to time,

of which the only one of value to survive is the Panama hat palm, *Carludovica palmata.* Large quantities of Lyon beans and okra seed and some robusta and liberian coffee seed were grown for distribution in 1910.

During 1911, 360 varieties of upland rice, 20 varieties of Philippine corn, a large assortment of native vegetables and a large number of imported forage plants were tested. During the same year a stallion, several burros, hogs, goats and sheep were received from Manila for breeding purposes.

When, with the appointment of Mr. F. C. Kingman as superintendent, in March, 1912, the writer was charged with the general direction of the station activities, the Lamao experiment station, barring its isolated location, seemed to be the most desirable point available at which to centralize the horticultural work of the Bureau. In July of the same year the writer formulated a plan for the centralization and conduct of the experimental horticultural work at Lamao, including the abolishment of the animal husbandry work and the transfer to other stations of all live stock at Lamao not necessary for the conduct of the work, the grading and replotting of the station fields, the establishment of a collection of tropical and citrus fruits, and practical training in horticulture of employees of the Demonstration and Extension Division before their detail to horticultural districts of the Archipelago. The work was later segregated into 15 separate projects. This plan was approved by the then Director of the Bureau, Mr. F. W. Taylor, and the then chief of the division of horticulture, Mr. O. W. Barrett.

The reorganization plan was carried into execution at once, and before the end of the year the leveling of the fields and the construction of new roads and irrigation ditches were well under way. Since then the rearrangement of the station has steadily progressed until, in the fields now under cultivation, it is nearly completed. This work has involved more or less leveling of all the fields in order to facilitate irrigation, the completion of a woven-wire fence 2920 meters around the station, the laying of 192 meters of cement drains, the construction of 2.83 kilometers of roads, 17 culverts, and irrigation ditches measuring 2,135 meters in mains and 4,034 meters in laterals, with 25 wooden flood gates. In most instances the irrigation ditches parallel the roads or edges of the fields and during the rainy season serve as drains. Royal palms, *Roystonea regia,* date palms, *Phoenix dactylifera,* Washington palms, *Washingtonia robusta,* and Canary Island date, *Phoenix canariensis,* have been planted out along the roads.

The grounds surrounding the office and the residence of the superintendent (Plate I, frontispiece) have also been drained and remodelled and a new road (Plate IV, *a*) including seven bridges of bamboo has been made from the office through the nipa swamp leading to the experimental fields. A propagation shed of bamboo (Plate II, *b*) covering 1,100 sq. meters was built in 1914; this has now been enlarged to 1,500 sq. meters.

During its session of 1912–13 the Philippine Legislature made a special appropriation for the construction of a plant-propagation shed and store house (58 by 7 meters) (Plate II, *a*), an animal shed, an irrigation plant, a concrete compost pit, a concrete dam, and a telephone line from Lamao to Limay; this legislation made possible the completion of the equipment and the present expansion of the work.

Under the reorganization plan the work of Lamao was separated in January, 1913, into the following fifteen projects: Tropical fruits, citrus fruits, pineapples, avocados, mangos, papayas, spices, nursery work, tropical rootcrops, vegetables, seed growing, apiculture, live stock, maintenance, and extension. The following is a brief summary of the work accomplished on each project to date.

Tropical fruits.—This project has necessarily occupied more time and attention than any other, and comprises all the tropical and subtropical fruits excepting those that have been made the subjects for separate projects.

One of the main features of the work has been the establishment of a collection of most of the tropical fruits found in the Philippines and the introduction of a large number of fruits heretofore not cultivated in the Archipelago, for which purposes three fields in the station have been reserved. Including the species already mentioned, most of which were transplanted to the new site, the tropical-fruit arboretum at the end of 1913 contained the following species:

Chico-mamey, *Lucuma mammosa;* mabolo, *Diospyros discolor;* zapote negro, *D. ebenaster;* casimiroa, *Casimiroa edulis;* tamarind, *Tamarindus indica;* barobo, *Diplodiscus paniculatus;* guava, *Psidium guajava;* genipap, *Genipa americana;* yaruma, *Cecropia palmata;* date, *Phoenix dactylifera;* iba, *Cicca disticha;* hevi, *Spondias cytherae;* rambutan, *Nephelium lappaceum;* bobog, *Sterculia foetida;* pangui, *Pangium edule;* yambo, *Eugenia jambos;* duhat, *E. jambolana;* phalsa, *Grewia asiatica;* bael, *Aegle marmelos;* vilatti, *Feronia elephantum;* kayam, *Inocarpus edulis;* biriba, *Rollinia orthopetala;* caraunda, *Carissa carandas;* pulasan, *Euphoria mutabile;* macadamia, *Macadamia ternifolia; Fla-*

courtia cataphracta; kambog, *Dillenia speciosa;* pomegranate, *Punica granatum;* durian, *Durio zibethinus;* cherimoya, *Annona cherimolia;* sugarapple, *A. squamosa;* mamon, *A. glabra;* soursop, *A. muricata;* and custardapple, *A. reticulata.*

The following species were planted in 1914: feijoa, *Feijoa sellowiana;* kaffir plum, *Aberia caffra;* ketembilla, *A. gardnerii; Britoa acida;* cattley guava, *Psidium cattleianum;* cos, *P. friedrichsthalianum;* guisaro, *P. molle;* carissa, *Carissa arduina;* Barbados cherry, *Malpighia glabra;* akee, *Blighia sapida;* ceriman, *Monstera deliciosa;* hog plum, *Spondias lutea;* alubihod, *S. mangiferae;* nelli, *Phyllantus emblica;* tiessa, *Lucuma rivicoa* var. *angustifolia;* caymito, *Chrysophyllum cainito;* banauac, *Uvaria rufa;* carambola, *Averrhoa carambola; Vangueria edulis;* juany, *Mangifera odorata;* breadfruit (rima), *Artocarpus communis* (seedless) ; marang, *A. odoratissima.*

The following species were planted in 1915: seagrape, *Coccoloba uvifera; Coccoloba* sp. (from Nicaragua) ; catmon, *Dillenia philippinensis;* hondapara, *D. indica;* grumichama, *Eugenia brasiliensis;* macopa, *E. malaccensis; E. edulis;* pitanga, *E. uniflora;* lipoti, *E. curranii;* macupa, *E. javanica; Eugenia* sp. (from Philippines) ; bignay, *Antidesma bunius;* camia, *Averrhoa bilimbi;* santol, *Sandoricum koetjape;* mastic, *Sideroxylon mastichodendron;* icaco, *Chrysobalanus icaco;* lemoncito, *Triphasia trifoliata;* cubili, *Cubilia blancoi;* soncoya, *Annona purpurea;* anigli, *A. senegalensis; Rollinia* sp. (from South America) ; calumpit, *Terminalia edulis;* bilucao, *Garcinia bilucao;* wampi, *Cookia punctata; Rheedia edulis;* alacao, *Palaquium philippinense;* Brazil nut, *Bertholletia nobilis;* litchi, *Litchi chinensis;* longan, *Nephelium longanum;* pili, *Canarium ovatum;* chico, *Achras sapota* var. St. Croix; *Psidium laurifolium;* rambi, *Baccaurea motleyana;* Barbados gooseberry, *Pereskia aculeata;* gomihan, *Artocarpus elastica;* jak, *A. intergrifolia;* lanzon, *Lansium domesticum;* granadilla, *Passiflora quadrangularis; P. laurifolia;* bitungol, *Flacourtia sepiaria;* and salak, *Zalacca edulis.* This makes a total collection of 93 species of fruits without including the citrus fruits, pineapples, mangos, avocados, Muscadine grapes and papayas.[1]

[1] To the very great interest in plant-introduction work of Mr. O. W. Barrett and the generosity of botanical institutions abroad is due a very large share of the plant collection at Lamao. The Siamese pomelos and various interesting plants were procured by Mr. H. H. Boyle, formerly assistant horticulturist. Until 1913 practically all the seeds received by the Bureau were propagated at the Singalong experiment station and the plants later shipped to Lamao.

A small orchard of the seedless breadfruit has also been planted in order to provide propagation material of this valuable fruit in the future, and some 30 plants of the marang, *Artocarpus odoratissima*, in the hope that some plants of this delicious fruit may become acclimatized here.

Seventy plants of the following Muscadine grapes, introduced during 1913–14, were planted in the field in 1915: James, Thomas, Eden, Lasalle, Mish, Labama, Flowers, Scuppernong, San Melaska and San Jacinto. These varieties were interplanted with male Muscadine vines which were introduced in order to insure fruiting. (See this REVIEW, Vol. VI (1913), No. 1, p. 28.)

Among the fruits planted up to 1914, the genipap, yaruma, bael, carissa, caraunda, cattley guava and *Flacourtia cataphracta* have fruited.

Several budded cherimoya varieties have been introduced for propagation and dissemination to the higher elevations and for hybridization with the lowland annonas, such as the sugar apple, custardapple and soursop. Grown on mamon stocks these cherimoyas have made fair progress. Three varieties of superior budded guavas have also been introduced.

Seeds obtained by crossing the sugarapple and cherimoya in Miami, Florida, U. S. A., were brought to the Philippines in 1911 by the writer, from which 24 hybrid seedlings were raised and planted at Lamao. One of these fruited in 1913 and 19 more fruited for the first time in 1914, yielding about 200 fruits. When the atemoyas, as the hybrids have been named, bloomed, they were crossed with the "Giant" cherimoya from Australia, the sugarapple, and the custardapple, with the result that there are now growing at the station 17, 21 and 73 hybrids, respectively, of these new combinations and 261 second generation atemoyas.

All the atemoyas were disappointingly small. The quality of the one which fruited in 1913 was excellent; of those that fruited in 1914 none was inferior to the sugarapple, while several were distinctly superior and more or less intermediate in quality between the cherimoya and sugarapple. Both the atemoya and the cautemoya, as the custardapple-atemoya seedlings have been named, are of exceptional vigor; the other two combinations about equal the sugarapple in vigor.

One hundred seedlings of the hevi and 128 of the banauac, and smaller numbers of various other species have been planted for breeding and selection work. Sweet-fruited varieties of the camia and carambola, and a superior variety of santol have been established by means of budding.

The Victor and Rico roselle, introduced in 1911, and the Archer, introduced in 1913, have been improved; one variety, the Temprano, 20 days earlier than the ordinary kinds, was isolated in 1911 and named in 1914, after three seasons' selection and testing. What is apparently an accidental hybrid of value between the Rico and Victor has been isolated during the past season. Yield tests of herbage and fruit of roselle were made in 1912 in connection with the Bureau of Science experiments in making wine and fruit syrups from the herbage. (See this REVIEW, Vol. VI (1913), No. 5, p. 223.)

In order to pave the way for their standardization, and to make possible the propagation of individual superior trees, considerable attention has been paid to experimental work in asexual propagation of exogenous tropical fruits, chiefly with shield budding, this being considered the most desirable of all methods. (See Current Notes, p. 135.)

In the course of this work a successful method of propagating the seedless breadfruit (rima) has been discovered, and in the following species the feasibility of shield budding has been demonstrated and the details of procedure worked out: cacao, *Theobroma cacao;* cashew, *Anacardium occidentale;* durian *Durio zibethinus;* carambola, *Averrhoa carambola;* casimiroa, *Casimiroa edulis;* camia, *Averrhoa bilimbi;* duhat, *Eugenia jambolana;* genipap, *Genipa americana;* hevi, *Spondias cytherеae;* santol, *Sandoricum koetjape;* barobo, *Diplodiscus paniculatus;* phalsa, *Grewia asiatica;* seagrape, *Coccoloba uvifera;* hondapara, *Dillenia indica;* vilatti, *Feronia elephantum;* nelli, *Phyllanthus emblica;* bignay, *Antidesma bunius;* calumpit, *Terminalia edulis;* mabolo, *Diospyros discolor;* iba, *Cicca disticha;* bael, *Aegle marmelos; Flacourtia cataphracta;* and banauac, *Uvaria rufa.* The possibility of shield budding the following additional species has also been proven: ketembilla, *Aberia gardnerii;* cattley guava, *Psidium cattleianum;* zapote negro, *Diospyros ebenaster;* alupag, *Euphoria cinerea;* Barbados cherry, *Malphigia glabra;* bitungol, *Flacourtia sepiaria;* catmon, *Dillenia philippinensis;* and feijoa, *Feijoa sellowiana.*

The lanzon has been grafted as well as shield budded. In budding experiments with *guttiferous* plants it has been found that the Palo Maria, *Calophyllum inophyllum,* can be shield budded, and it is worthy of note that the mangosteen takes on *Garcinia venulosa,* though the buds failed to make growth.

It has also been demonstrated that the custardapple can be budded on the sugarapple and soursoup, the biriba, *Rollinia orthopetala,* on the mamon, *Annona glabra,* soursop, custard-

apple and *Annona montana*. The orange, pomelo, mandarin, lemon, lime, and citron have been found to take well and make a good growth on the calamondin, *Citrus mitis*. These citrus fruits have also been recently budded on the cabuyao, *Citrus histrix*.

In the course of the above experiments it has developed that certain species, in order that the work may be successful, require that the leaves shall have been removed from the budwood, while still on the tree, sufficiently in advance of the performance of the budding to permit the formation of a well-healed leaf scar; in other species one of the essential points is that the budwood and the stock at the point of insertion be of approximately the same age and appearance; a species may require the observance of one or both these rules; finally, in a third class, including by far the largest number of species, the plants are indifferent whether or not these conditions are observed. In so far as the writer's experience goes, the first class, containing species that require the use of non-petioled, well-matured budwood, includes the mango, cacao, cashew, etc.; here belong also the annonaceous plants, the budwood of which should be sufficiently matured to have completely lost its green color. The second class includes those in which the budwood and the stock at the point of insertion should be of approximately the same age and color; namely, the mango, cacao, hevi, cashew, santol, etc.; in some of these species, for instance in the mango and hevi, the budwood, though ripe, is green, but in most species it changes to another color. The third class, containing those species of which budwood with the adhering petioles may be used, includes among others the citrus fruits, guava, tamarind, carambola, barobo, etc.

Citrus fruits.—The mandarin is one of the commercially important fruits in the Philippines, and there is every reason to believe that some of the other citrus fruits would also become of equal importance if good varieties were introduced and, together with the best Philippine types propagated by budding, planted in suitable localities and properly handled. Considering also the enormous wealth of original forms of the genus *Citrus* in the Philippines, the citrus fruits have therefore been accorded attention second only to the tropical fruits.

It has already been noted that during 1910 plants of the Bahia, Mediterranean, Navelencia, and Washington Navel orange, and the Belair, Lisbon and Villafranca lemon varieties were introduced from Australia and planted at Lamao.

A study of the Philippine citrus fruits by the writer in 1911

showed the urgent necessity of further importation of the standard citrus varieties cultivated in other countries, and during 1912, 1913 and 1914, the following citrus varieties were imported:

Oranges: Bessie, Boone, Brown, Centennial, Enterprise, Everbearing, Excelsior, Holdfast, Homosassa, Joppa, Larrantta, Majorca, Malta Blood, Maltese oval, Nonpareil, Paperind, Pineapple, Ruby, Tardiff, St. Michaels, Blood, Navelencia, Valencia, Vini, Vinous, White Siletta, St. Jago, Foster, Carleton, Magnum Bonum, Duroi, Dugat.

Pomelos: Royal, McCarthy, Walters, Duncan, Ellen, Marsh, Pernambuco, Siam, Triumph.

Mandarins: China, Dancy, King, Kishiu, Ladu, Oneco, Satsumamikan, Suntara Nagpur, Unshiu.

Lemons: Messina, Lisbon, Lisbon variegated, Sicily, Thornless.

Limes: Bengal, Tahiti, Everglade, Trinidad.

Tangelos: Sampson.

Four varieties of the mandarin, four of the tizon and one pomelo of Philippine origin have been found that merit general dissemination and are being propagated for distribution.

Owing to the fact that practically nothing was known relative to the wild or semicultivated citrus forms in the Archipelago, an attempt has been made to assemble these forms at Lamao both for the purpose of identification and to determine their economic value. A large collection, containing 141 serial numbers of Philippine citrus trees, has been planted, including the following species: *Citrus aurantium* L., *C. vulgaris* Risso, *C. nobilis* Lour., *C. nobilis* var. *papillaris* Blanco, *C. decumana* L., *C. mitis* Blanco, *C. webberii* Wester, *C. webberii* var. *montana* Wester, *C. longispina* Wester, *C. southwickii* Wester, *C. macrophylla* Wester, *C. histrix* DC., *C. histrix* var. *torosa* Blanco, *C. histrix* var. *boholensis* Wester, *C. micrantha* Wester, *C. micrantha* var. *microcarpa* Wester, *C. medica* L., *C. medica* var. *odorata* Wester, *C. medica* var. *nanus* Wester, *C. limonum* Risso, *C. pseudolimonum* Wester, *C. limetta* Risso, *C. limetta* var. *aromatica* Wester, *C. excelsa* Wester, *C. excelsa* var. *davaoensis* Wester.

Aside from those lots that belong to the above-named species there are a number of forms, the plants of which are still too small to admit of their identification, some of which may belong to other species. For full descriptions of the species mentioned see this REVIEW, Volume VIII (1915), No. 1, page 5.

The imported varieties as well as a few Philippine kinds of merit are mostly budded on the sweet orange and pomelo. A few have been budded to various native citrus stocks, such as the calamondin, *C. mitis*, alsem, *C. webberii*, *C. excelsa* var. *davaoensis*, etc. The budded trees have been planted in an

orchard, 2 trees of each variety 4 x 8 meters apart. The seedling trees are planted 3 by 4 meters apart, 1 to 20 of each lot, for testing and observation depending upon individual variation and its hypothetical horticultural value.

Pineapples.—This is one of the minor projects, and the work has been confined to the introduction and planting of Cayenne and the Spanish from Hawaii, the Abakka, Cabezona, Sugarloaf, and several hybrids, among others the Eden and Deliciosa, from south Florida. As previously stated the Queen was introduced some years ago.

There are now growing at Lamao approximately 2,000 Queen, 2,000 Cayenne, 1,000 Spanish, 200 Sugarloaf and some 300 plants including all the other varieties mentioned. Of these the Queen, Cayenne and Spanish have made excellent growth and shown themselves well adapted to the climate and soil. The Cayenne particularly comes up to all anticipations and this variety is so superior to all others for home consumption and canning that they cannot even be considered as its competitors under equal conditions. The principal use of the Spanish would seem to be for exportation of fresh fruit to Hongkong, China and Japan.

The remaining varieties have not shown the adaptability of those just mentioned, though fair progress has been made by the Abakka, Sugarloaf and Eden. It is hoped that at least the two first-named varieties may adapt themselves to the country, since because of their late fruiting habit they would prolong the pineapple season several months.

Avocados.—This fruit was made a separate project more because of its potential than its present and actual value to the Philippines. As already stated a small avocado orchard was planted at Lamao some years ago. Most of these trees have fruited, but only two have borne sufficiently meritorious fruit to be worthy of propagation, one of which was named and propagated for distribution last year.

Budwood has been received of named varieties from Hawaii, California and Florida, including several of the best avocado sorts in these countries and has been successfully budded with the result that the station now has 34 budded varieties, most of which have been received from the United States Department of Agriculture.

Mangos.—Due to the fact that the ordinary Philippine seedling mango is already a superior fruit, comparatively little attention has been paid to it, especially considering that the mango is one of the most common fruits in the Archipelago.

A recent improvement in the budding of the mango has been

made by demonstrating definitely the advantage of using non-petioled instead of petioled budwood (see this REVIEW, Vol. VIII (1915), No. 1, p. 59), in connection with which it may be of interest to know that the juany, *Mangifera odorata* Griff., shield budded on the mango by Mr. H. H. Boyle is making excellent growth on this stock.

The following inarched varieties have been imported from India and are now well established: Naspati, Gopalbhog, Tamancha, Krishna Bhog, Sandurea, Chickna, Bombay green, Alfonso, Malda, Kachamitha, Davy's Favorite, Langra, Kutna, Salibunda, Sufaida, Kakaria, Surkha and Najibabadi Amin.

Papayas.—A large papaya orchard has been maintained year after year for seed production and distribution, and now includes 314 plants. All males and all undesirable pistillate trees are being destroyed as soon as their true characters appear and seed is sown from the best hermaphrodite fruits. The result of this simple method of improving the strain, within reach of every papaya grower, is that an unusually good strain has been developed within a very short time and is gradually becoming disseminated throughout the Archipelago.

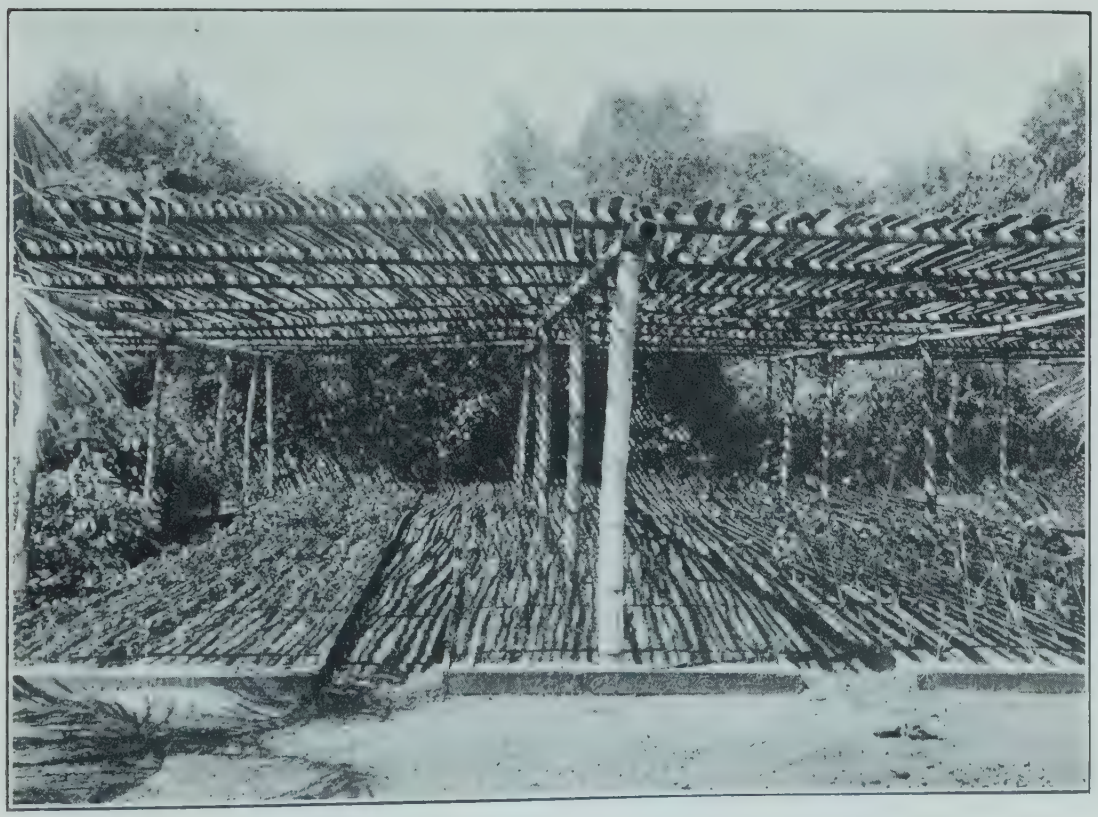
Spices.—It cannot be doubted but that spices in certain parts of the Islands would be a profitable crop; ginger and black pepper are indeed grown here and there. The long dry season and the short wet season with a very heavy rainfall, characteristic of Lamao, is not well suited to most spice plants, and the planting in the field of the vanilla and cardamon resulted in the failure of both though the plants were strong and vigorous, and the project is temporarily suspended.

Nursery work.—With the erection of up-to-date propagating houses, the installation of an adequate irrigation plant, and the improvement of the surface irrigation system, the nursery operations have increased from the propagation of some 700 plants in 1911 until, at the end of the year 1914, the nursery at Lamao contained the following plants:

Citrus trees of standard varieties, budded	2,548
Annonaceous plants, budded	373
Avocados, budded	160
Tropical fruits, seedlings, miscellaneous species	5,537
Annona hybrids	364
Citrus stocks, various species	8,269
Annonaceous stocks	1,629
Miscellaneous economic and ornamental plants, not fruits	4,825
Total	23,705



(*a*) Plant propagation shed, Lamao Experiment Station, 1914.



(*b*) Section of bamboo plant propagation shed, Lamao Experiment Station, 1915.



(*a*) Main road leading from Manila Bay to the experimental fields, Lamao Experiment Station, 1914.

The office building on the right, and the residence of the superintendent, on the left, are concealed by the shrubbery.



(*b*) Road through citrus orchard and nursery, Lamao Experiment Station, 1914.



(*a*) Road through nipa swamp from office and residence to experimental fields, Lamao Experiment Station, 1914.



(*b*) Seed-growing, Lamao Experiment Station, 1914—"India" cucumber in the foreground, seguidilla, *Psophocarpus tetragonolobus*, and lima beans in the background.

During the same year, 1914, the plant distributions were as follows:

Citrus trees, standard varieties; budded	813
Atemoyas, budded	37
Tropical fruits, seedlings, miscellaneous species	1,305
Citrus stocks	183
Pineapple suckers and slips	16,153
Maguey suckers	16,600
Yams (tubers)	1,045
Mulberry cuttings	6,000
Miscellaneous cuttings	200
Citrus scions (22 varieties)	196
Total	42,532

From July 1, 1912, to December 31, 1913, 294,300 maguey suckers and bulbils were distributed but the demand has now lessened to such an extent that the upkeep of the maguey field has been largely abandoned; likewise, with the diminished demand for mulberry cuttings (of which 28,000 were distributed during the year ending June 30, 1913) the old mulberry plants have been gradually removed and superseded by some 75 plants of the best white mulberries imported from France.

Tropical rootcrops.—This project is confined to yams. A few yams had been grown for observation, and a small collection was sent to Lamao early in 1911, but no particular care was given these plants and practically all were lost. During the First Philippine Exposition in Manila (February, 1912), the writer procured a large collection of yams including *Dioscorea alata, D. aculeata* var. *tiliaefolia, D. pentaphylla,* and *D. triphylla* from the provincial exhibits, some of which had unusually good yam collections. Most of the tubers included in this lot were sent to Lamao, while a small duplicate collection was set out at the Singalong experiment station. During 1912 and 1913 it was increased by a number of Philipine and foreign accessions until at the present date the yam collection at Lamao includes over 70 accession numbers. Many of these lots are, however, necessarily duplications of each other.

At the end of each season the tubers were replanted until, in 1914, 0.5 hectare was devoted to yams. With the analyses being made by the Bureau of Science, the records kept of the behavior of the plants, and with the elimination of the less desirable types, the preliminary testing work will be completed before the planting season for 1915 shall have opened, and the future work will consist largely in the propagation of the desirable forms. It is already evident that of the various species now found in

the Archipelago only *Dioscorea alata* and *D. aculeata* var. *tiliaefolia* are worthy of cultivation. There are, however, several extra-Philippine species of excellent qualities whose introduction would unquestionably be desirable.

Vegetables.—The vegetable tests in 1913 included 95 table beans, 12 varieties of cucurbits and 12 varieties of sweet corn. The bean trial was particularly interesting and showed that several varieties might be profitably cultivated in the Philippines. The yields per hectare of the six most promising varieties, according to records kept by Mr. Kingman, were as follows: Early Mohawk, 1,388 kilograms; Dwarf Horticultural, 892 kilograms; Round Yellow, 832 kilograms; Wardwell's Kidney Wax, 573 kilograms; Black Valentine, 545 kilograms; and Dreer's White Wax, 527 kilograms. These yields were computed from small plats grown of each kind and the yields probably would be 10 to perhaps 15 per cent lower in field culture.

The sweet corn made a stunted growth but several varieties produced ears of excellent quality.

The forage and cover-crop trials, started in 1911 and continued through 1912, were concluded in 1913 with a test of 62 separate varieties in which were eliminated all legumes included as cover-crops for the Philippines excepting the Lyon bean, the New Era cowpea, 3 varieties of mungos, the guar and the Florida Beggarweed. The New Era cowpea yielded seed at the rate of 1,055 kilograms per hectare. A detailed account of the vegetable and forage trials above referred to was prepared by Mr. Kingman who was in charge of this work. It appears elsewhere in this issue of the Review.

During the season 1913 and 1914, 22 imported varieties of cucurbits, 9 varieties of okra and a few bean varieties were tested, none of which yielded anything worth further trial. Among the climbing lima beans the most promising is a white variety obtained by the writer in 1912 in Bukidnon, Mindanao, where it is said to grow wild in the mountains; in fact this is the only lima that has been retained as worthy of future breeding work. The India cucumber, named and described in this REVIEW, Vol. VII (1914), No. 2, page 80, is the only cucurbit that has been found worthy of distribution.

Seed growing.—This project may be said to have been begun in 1910, when large quantities of Lyon beans, okra and papaya seed, and some liberian and robusta coffee were first grown for distribution. Since then seed growing has been part of the station activities and seed in greater or less quantities has been produced for distribution annually through the central office

of the Bureau in Manila. The list of these seeds includes the following plants: Lyon beans, New Era cowpeas, mungos, table beans (several varieties), seguidillas, okra, roselle, papaya, corn, cadios and cucumber. Most of the seed crops are cowpeas and Lyon beans, and since these plants are grown as cover crops between the trees in the orchards, they serve a twofold purpose with practically no additional cost except the harvesting of the seed. This year all the tillable land not otherwise occupied is planted to cowpeas, guar, seguidillas, corn and cucumbers, something more than a hectare being devoted to this last mentioned crop. During the last four years the practice has been to annually plant Lyon beans before the advent of the rainy season on land not occupied with other crops and to harvest them shortly after the beginning of the dry season. After the harvest of the Lyon beans the land is then planted to cowpeas, corn, etc. Two successive crops of cowpeas, for instance, are easily harvested in one dry season on the same land.

The cowpea and Lyon-bean vines, etc., are used either as mulch around the trees or plowed under.

Apiculture.—Six hives of bees, imported from Hawaii and Guam, were transferred from the Singalong experiment station to Lamao in December, 1912, but the colonies failed to thrive and the project is temporarily suspended.

Live stock.—Before the reorganization of the station this project covered all animal breeding work conducted at Lamao; at the present time it covers only the work animals (six Chinese bullocks) and their care.

Maintenance.—To this project is charged all expenditures for repair of buildings, the upkeep of fences, roads, etc., and transportation between Lamao and Limay.

Extension.—This covers all work not directly related to any of the above mentioned projects, such as construction work, drainage, or clearing of new land, etc.

Since December, 1912, nine young men have received practical training in horticulture at Lamao before being detailed to the provinces by the Demonstration and Extension Division of this Bureau.

The writer wishes to express his appreciation for the loyal support received from his coworkers and subordinates, which has made possible the accomplishment of a remarkable amount of work in a comparatively short space of time. Particularly appreciated are the services of Mr. F. C. Kingman, to whom fell much of the detail work in connection with the reorganization of the station, who was in full charge of the construction

work, and who directed the labor during 1912, 1913 and 1914. Up to December, 1914, all experimental work in asexual propagation of tropical fruits was conducted in person by the writer; since then, with the extension of the work to a large number of species, most of the work has been performed by Mr. Francisco Galang, Mr. Severo Capistrano and Mr. Bernabé Malvar, agricultural inspectors.

During the earlier years of the existence of the station much time was necessarily occupied in clearing the land, and the changes that have been made during the last three years, together with the construction work, have left comparatively little time for experimentation. This labor is now practically completed, making the future work largely routine and experimental until the cultivable area is extended. A nucleus of plants has also been assembled which, together with what is readily procurable in the Philippines or neighboring countries, will provide good working material for many years to come.

By these permanent improvements made within the last three years, the actual and particularly the potential value of the Lamao experiment station is now greater than that of any other of the plant industry experiment stations maintained by the Bureau of Agriculture in the Philippine Islands. Land of good quality, easily and cheaply irrigated, is available in areas sufficient to meet any demand for extension. With the construction of the concrete dam and the new ditches completed last year, an area twice as large as the present one can be brought under cultivation without further irrigation expense than that of digging the necessary laterals, and still greater enlargements of the tillable area for several years would merely require the deepening and widening of the main ditch. The location for a laboratory and residences for the workers is ample, attractive, practically free of mosquitoes throughout the year, and, being located on the seashore, is much cooler than the interior of the Islands. Everything considered, should it appear desirable to concentrate the plant industry research work of the Bureau at any one point, so far as the climatological requirements of the plants will permit and with a view to increasing efficiency and reducing expenses, the Lamao experiment station is the logical point for such concentration.

VEGETABLE AND COVER-CROP TRIALS AT THE LAMAO EXPERIMENT STATION.

By F. C. KINGMAN, *Agricultural Inspector.*

In the work of seed distribution the Bureau of Agriculture has, for a number of years, obtained the larger portion of its seeds from a seedhouse in Australia. Considerable quantities of seeds have also been purchased from various firms in the United States and Europe, with the object in view of determining their relative value, as shown under test, so that, in the future, preference may be given to those firms whose seeds have shown the best results in the tests. In addition, it was hoped to discover some varieties which would be particularly adaptable to Philippine conditions, making it possible to grow them in large quantities for use in the seed-distribution work of the Bureau; for, aside from the expense incident to the purchase of seeds from abroad, they have not always been in good condition upon their arrival here and they deteriorate rapidly in germinative power in this climate. It was believed that this difficulty might be largely overcome if a more or less constant supply of home-grown seeds was available. Accordingly, ninety-five varieties of table beans, nine varieties of cucurbits and ten varieties of sweet corn were sent to the Lamao experiment station to be tested with reference to cultural methods, edibility and productiveness.

The tests were begun in the month of December, 1912, continued through the cool season and concluded toward the close of the dry season in 1913. The season of the year apparently had no detrimental effects upon the growth of the table beans, cover crops and sweet corn, but the poor results obtained from the cucurbit trials were largely due to lateness of planting.

The preparation of the seed beds for the various tests was practically the same. The soil was first irrigated and, after a few days when sufficiently dry, it was plowed, disked, harrowed and smoothed with a plank drag. All varieties of table beans were sown thinly in drills with the rows 60 centimeters apart,

the cucurbits in hills 2 meters apart each way, the corn in check rows 1 meter apart each way, and the cover crops thinly in drills 1 meter apart. Exception was made with some of the mungos, however, they being sown in the same manner as the table beans and the Lyon beans which were given a distance of $1\frac{1}{2}$ meters each way. In planting the table beans and a few varieties of the mungos, a marker, made like a large rake with teeth every 60 centimeters, was used. This implement, when dragged over the field, marked out the rows which were later furrowed out with a plow. The seed was then sown and covered with the hoe. In planting the varieties of sweet corn and cucurbits a similar marker was used which check-rowed the former in hills 1 meter each way and the latter in hills 2 meters each way. The cowpea cover crops were drilled in, in rows 1 meter apart, a plow being used to open the furrows. In planting the Lyon beans as a cover crop, a marker was used and the beans planted in hills $1\frac{1}{2}$ meters apart each way, 2 to 3 beans to the hill. The sowings of table beans were started during the latter part of December and continued from time to time, as the seeds were received, until as late as May.

As all the tests were conducted during the dry season, irrigation was necessary on an average of every ten days. This was accomplished by flooding the plots with water from an open ditch. For the sweet corn, cucurbits and all tests where the planting was made in rows 60 centimeters apart, a fire-shovel cultivator was used for cultivation purposes. However, in some instances, where the nut grass was very bad, it was necessary to use hoes. It was the custom to cultivate a few days after irrigation, just as soon as the soil was sufficiently dry. In cultivating the cowpeas and Lyon beans a twelve-tooth cultivator was used. The Lyon beans received little or no irrigation. The pole varieties of table beans required the making of trellises which was accomplished by setting bamboo posts 2 meters in length along the rows at intervals of 4 meters, and attaching to these, with bejuco, two bamboo strips running horizontally, one about one-half meter above the other.

Notes were taken on all the table-bean varieties showing the source (seed house), date of planting, germination, stand, habit of growth, flowering, date edible, date of maturity, productiveness, vigor, average length of pods, average thickness of pods, average number of beans in pods and amount of fiber. In a number of plots where, due to the previous leveling of some of the fields, the surface soil had been removed thus exposing the

acid subsoil, the plants under these adverse conditions, in most cases, made a very poor growth. In other plots where it was difficult to control the nut grass, a number of varieties also made a poor growth. It is very likely that some of the varities grown under the conditions just mentioned were not inferior in vigor but made a poor showing because of the poor soil conditions. The following six varieties, considered the best, were selected and their yields per hectare computed:

		Kilos.
L–54.	Wardell's Kidney Wax beans	573.75
L–56.	Black Valentine beans	545.50
L–59.	Early Mohawk beans	1,156.00
L–61.	Dreer's White Wax beans	527.62
L–62.	Dwarf Horticultural beans	892.50
L–63.	Round Yellow beans	823.80

Thirty different kinds of cover crops were tested as given in the following list:

Lyon beans.
P. I. 1669. Soy bean.
New Era cowpeas.
Clay cowpeas.
L. 53. Iron cowpeas.
Brabham cowpeas.
Groit cowpeas.
P. I. 665. Peanuts.
Guar (*Cyamopsis psoralioides*).
L. 10. *Lathyrus tingitanus.*
P. I. 2398. *Vicia faba.*
P. I. 2400. *Lens esculenta.*
P. I. 2399. *Cicer arietinum.*
P. I. 2401. *Cicer arietinum.*
P. I. 1585. *Stizolobium deeringianum.*
P. I. 1586. *Stizolobium aterinum.*
P. I. 278. *Phaseolus calcaratus.*
P. I. 1534. *Phaseolus calcaratus.*
P. I. 279. *Phaseolus mungo.*
P. I. 1112. *Phaseolus mungo.*
Phaseolus mungo.
P. I. 1195. *Phaseolus* sp.
P. I. 1952. *Phaseolus* sp.
P. I. 2056. *Phaseolus* sp.
Phaseolus sp., No. 1.
Phaseolus sp., No. 4—Iloilo.
Phaseolus sp., No. 7.
P. I. 2470. *Phaseolus* sp., Japanese.
Phaseolus aconitifolius.
P. I. 1951. *Phaseolus vulgaris.*

The Lyon beans gave excellent results, forming a thick dense growth over the ground and effectually choking out weeds. Part of the guar germinated very poorly and a good stand was not obtained from more than one sowing. However, judging from the growth of the plants where the stand was good, this legume promises to give excellent results as a cover crop. The remaining cover-crop legumes in the list tested gave unsatisfactory results and were discarded.

Of the cowpeas, the New Era far outranked the others in vigor of growth, ability to cover the ground and in seed production. The Clay cowpeas came next, followed by the Iron and Brabham in the order named. The Iron and Brabham cowpeas made a very poor growth and were discarded. Representative areas

were selected of both the New Era and Clay varieties and their yields per hectare computed as follows:

	Kilos.
New Era cowpeas	1,065
Clay cowpeas	804.67

Four varieties of mungos, one green seeded, one black seeded and two yellow seeded, gave good results as cover crops. They covered the ground well, choked out the weeds and, in addition, gave good yields of seed. The yields of seed per hectare were as follows:

	Kilos.
Green-seeded mungos	530.5
Black-seeded mungos	623
Yellow-seeded mungos	748.2
Iloilo No. 4 Yellow-seeded mungos	801.4

The varieties of cucurbits tested were as follows:

No. 16. Watermelon.
No. 17. Squash, Early white bush scallop.
L–66. Muskmelon, Rocky Ford.
L–67. Squash, Fordhook.
L–68. Muskmelon, Large yellow.
L–69. Cucumber, India.
L–70. Squash, Mammoth summer.
L–71. Squash, Yellow summer crookneck.
L–72. Watermelon, Cole's early.

Due partly to planting late in the season (January), but mainly to the voracious attacks of insects, the cucurbit trials were failures, with one exception. The plants were frequently dusted with a mixture of Paris green and lime but this failed to hold the insects in check. One variety of cucumber, however, introduced from India (L–69 "India"), was apparently quite resistant to the insect attacks and did very well, producing an abundance of fruit. Four and one-half kilos of seed were harvested from an area of approximately 200 square meters.

The following varieties of sweet corn were planted January 15, and first picked for eating April 12.

L–83. Early white Cob, Corey.
L–84. Golden Bantam.
L–85. Golden Cream, Morse.
L–269. Black Mexican.
S–270. Golden Dawn.
S–271. Dreer's Golden Cream.
S–272. Dreer's First-of-all.
S–378. Early Minnesota.
S–382. Early Red Cob, Corey.
S–433. Stabler's Early.

The germination and stand of these varieties of sweet corn were excellent. All made a stunted growth but the production of ears was quite satisfactory, being of good length and well filled out. Notwithstanding the poor growth of the plants, the eating tests showed the quality of the corn to be excellent. The ears produced were very tender and sweet. Regarding yield, size of ears and quality of ears, the best varieties rank as follows:

S–271. Golden Cream.
S–378. Early Minnesota.
S–270. Golden Dawn.
S–272. Dreer's First-of-all.
S–433. Stabler's Early.

Conclusions.—Although experiments conducted for only one season are inconclusive, the results obtained from the table-bean trials aparrently indicate that some of the varieties can be grown successfully in the Philippines.

The large yields of seed from such varieties as Early Mohawk, Dwarf Horticultural and Round Yellow beans would seem to indicate that these varieties could be profitably grown for seed production.

Judging from the results obtained from the cover-crop trials the following six legumes may be recommended for that purpose:

Lyon bean.
New Era cowpea.
Guar.
Yellow-seeded mungo.
Black-seeded mungo.
Green-seeded mungo.

Where the climbing habit of the Lyon bean is not objectionable, it is, perhaps, the premier cover crop during the rainy season. Of the cowpeas tested, only one, the New Era, has been retained for future planting. The Clay cowpea did very well but the New Era is so far superior that, if obtainable, it should be given the preference. The remaining varieties have been discarded. As the New Era cowpea gave an abundant yield of seed, 1065 kilos per hectare, the growing of this legume for seed production may be recommeded.

The planting of the cucurbits late in the season and the consequent attacks of insects were responsible for the almost total failure of these trials. Only one variety survived the insect attacks and fruited well.

The good results obtained from several varieties of sweet corn are worthy of notice and encourage further tests of this crop.

SIRUP MANUFACTURE.

By CLEVE. W. HINES, M. S., *Station Superintendent.*

The manufacture of sirup for table use forms a very important industry in many countries, and this product, when properly made, is one of the cheapest and most wholesome articles of food. Sirup has long been considered a delicacy by various peoples, no doubt originally because of its similarity to natural honey, under which name it has often been sold. The varieties and sources of this product are very numerous. Among the most important classes may be mentioned the cane, palm, maple, and corn or glucose sirups.

CANE SIRUP.

This sirup consists of the juice of the sugar cane (*Saccharum officinarum*), boiled to the required consistency after receiving proper clarification, the degree of which will depend upon the original condition of the juice.

There is a wide difference in the purity of cane juices, some containing as high as 90 per cent of the total solids as sucrose while others will have as low as 50 per cent or less. The higher purity ordinarily indicates close proximity to maturity of the cane while the extremely low purity may be the result of several causes among which are: undermaturity, overmaturity, unfavorable weather conditions, windstorms, and injury by animals or insects. The low purity of a cane juice, however, may not always indicate an extremely low yield in sirup, though there is usually some diminution; but it may give a sirup with an entirely different flavor and other characteristics, since a portion of the crystallizable sugar (sucrose) will usually be changed into the invert sugars by a process known as inversion, and may affect the composition of some of the nonsugars. It has been recommended by some sirup makers that this class of cane be used in preference to ripe cane in order to make a sirup in which the sugar will not crystallize out, but this difficulty may readily be overcome in another manner which will be set forth later, and thus the change in other organic compounds may be avoided.

Some varieties of cane will give a lighter colored juice than others and this usually means a lighter sirup, especially when but little attempt at clarification is made. The coloring substance "anthocyan" is ordinarily not all removed by the limited amount of lime used in clarification and the remainder is not readily bleached by the sulphitation. It is therefore usually preferable to reject the darker varieties which contain this soluble pigment in profusion.

In the manufacture of a high grade sirup, only selected cane which is thoroughly ripe should be used. A maximum mill extraction is not best, since undesirable amounts of organic impurities, such as gums, are thus removed with the juice, which will cause a darker sirup with an inferior flavor. The juice from the rolls must be thoroughly strained to remove any large particles of bagasse or cane fiber and other impurities. It is then treated with a small quantity of milk of lime to precipitate some of the organic impurities. After this treatment it is either at once left to settle or first treated with sulphur dioxide gas.

Sometimes, however, this sulphuring of the juice is done before the lime is added. The sulphuring has the effect of raising the acidity of the juice so that more lime may be added to effect clarification. It also serves as a bleaching agent, making a brighter and lighter sirup, and causes the precipitation of some of the impurities. Care must be exercised that not too much of the sulphur gas be used, since an undesirable amount of the sulphites will remain in the sirup which is not permitted by the Pure Food Law.

The clarified liquor, which remains above the impurities, should have a clear amber or straw color and is ready for evaporation. If there are still appreciable amounts of impurities present, this juice should be carefully filtered through bags while the settlings may be filtered through presses and this filtrate be clarified with the original juice.

Where a high grade sirup for direct consumption is made, this work of concentration is always done in open train evaporators (Plate V, *a*) under atmospheric pressure, since the highly desired aromatic flavors are thus preserved while in the vacuum type of evaporator these flavors are greatly impaired. The more modern design of open evaporator (Plate V, *b*) for this work has a steam space usually in the form of coils in the bottom of the evaporator which contain the steam for heating.

Water under atmospheric pressure at sea level boils at a temperature of 100° centigrade but when there is a quantity of sugar and other solid material present the boiling point will be

materially increased, depending upon the density of the solution. At the higher temperatures there is a noticeable amount of the sucrose inverted or changed into glucose, but this causes little harm to the resulting sirup so long as no caramel or burned sugar is produced by superheating.

Where the juice is boiled in kettles by the application of direct flames, there is always more or less caramel formed which is responsible for the bitter taste and dark color of many sirups. This is particularly true of the present method practiced in the older factories of the Philippines. After this evil has once presented itself, it is difficult, if not impossible, to make a good grade of crude sirup possessing the natural flavors of the cane juice.

Where such sirups are diluted and passed through bone-black filters the dark color is of course removed, and the resultant sirup will consist only of sucrose in solution and be equal in all respects to sirup made from a high grade sugar.

A question of very great importance to cane sirup manufacturers is the consistency to which the sirup should be boiled. This quality is often referred to by dealers as "body" and is usually judged quite accurately by men of experience. However, in the manufacture of sirup one should not be content with any "hit or miss" method in determining the density of his product, but should use a gravity spindle, either Baumé or Brix. By the aid of the following table these results may readily be transferred from one to the other.

Table of comparison between Baumé and Brix spindles.

Degree Baumé.	Degree Brix.	Degree Baumé.	Degree Brix.
1	1.8	26	46.8
2	3.6	27	48.7
3	5.4	28	50.5
4	7.1	29	52.5
5	8.9	30	54.3
6	10.6	31	56.2
7	12.4	32	58.1
8	14.2	33	60.0
9	15.9	34	61.9
10	17.7	35	63.8
11	19.5	36	65.8
12	21.3	37	67.7
13	23.1	38	69.7
14	24.9	39	71.8
15	26.7	40	73.7
16	28.6	41	75.6
17	30.3	42	77.7
18	32.1	43	79.7
19	33.9	44	81.8
20	35.7	45	83.9
21	37.6	46	86.0
22	39.4	47	88.1
23	41.3	48	90.2
24	43.1	49	92.3
25	45.0	50	94.4

If the sirup is boiled to 39° or 40° Baumé (73° Brix) or total solids, it will ordinarily meet the requirements of dealers. Since the sirup boiled directly from the clarified juice of the cane will contain a large percentage of sucrose or crystallizable sugar and have a very high purity, there will be very great danger of the deposition of crystals if the sirup is made at all heavy; and again if the sirup is made too light in body there will be great danger of its deterioration by fermentation. If the purity of the sirup is so high that there is danger of crystallization at this density, a part of the sugar may first be crystallized out and removed, after which the sirup is again brought to the desired density, or better still, a part of the sugar may be changed into invert sugar or glucose by hydrolysis. This may be accomplished by the aid of acids, enzymes, heat, or other agents, but the simplest method for factory working is to add to the sirup a small quantity of a strong mineral acid and boil for ten minutes or more. As soon as the sirup has reached the proper consistency it should be placed in well-sterilized new containers and properly sealed while hot. Sirup which has been made under the above conditions should keep indefinitely without any sign of fermentation or deterioration.

PALM SIRUP.

Sirups have been made from the sap of various palm trees by the natives of tropical countries from time immemorial. The plants most commonly used for that purpose were the sugar palm, *Arenga saccharifera,* known in the Philippines as the kaong or cabo negro; the wild date palm, *Phoenix silvestris;* the nipa palm, *Nipa fructicans;* and the palmyra palm, *Borassus flabelliformis,* of the East Indies. In olden times the sirup was made in the very crudest manner for direct consumption and no attempt was made to properly clarify the juice before concentration, nor bring it to a heavy density for better preservation. In modern sirup manufacture it is necessary to boil the sirup to a heavy "body" in order to prevent fermentation setting in during the time of storage, since many palm sirups lend themselves readily to enzymic action subsequent to fermentation.

The sap from many of these palms has a very pleasant flavor when boiled only to a thin consistency, but when it is made heavy this flavor becomes more intense until it ceases to be considered pleasant.

The impurities, consisting mainly of organic nonsugars, impart the pleasant flavor to the sirup, but when they become decomposed upon prolonged heating, as in the case where a heavy

sirup is made, dark colored and stronger compounds are formed with the consequent lowering of the value of the sirup.

Where such sirups are made for the trade and must be stored for a long time, it will be necessary to subject the original sap to a preliminary clarification and to guard as far as possible against its being superheated when the sirup becomes heavy.

Absolute cleanliness throughout every part of the work must be exercised and special attention given to prevent fermentation of the saps before boiling. Such a fermentation would cause the decomposition of the sucrose as well as a change of some of the impurities, thus having the effect of lowering the sweetening power and also impairing the flavor of the final sirup.

In collecting the sap only clean and thoroughly sterilized containers which are made of noncorrosive metal, porcelain, etc., should be used. They should be provided with some form of a cover to prevent foreign substances from entering. Since the saps from the majority of the sacchariferous palms are usually subject to enzymic action, every possible means of minimizing this trouble should be used. In the first place, there must be a regular time for gathering the sap and extreme care exercised that it be not left to stand any longer than necessary without treatment. Usually not more than four to six hours should elapse between the collections and even then some form of germicide should be used to prevent fermentation. While a number of different chemicals will answer for this purpose, the most suitable one under ordinary circumstances will be formalin. An apparatus may very easily be arranged so that a few drops would be added from time to time during the flow of the sap. Calcium hydroxide, or calcium sulphite, may also be mixed very advantageously for this purpose and this would have the additional advantage of aiding in the clarification and precipitation of the impurities.

In clarifying the sap it should be placed in a large container and brought almost to the neutral point or made slightly acidic by the aid of sulphur or carbon dioxide. It should then be heated to the boiling point, cooled and settled, and the clear liquor drawn off. This heating process has the effect of removing some of the impurities, such as albumin and albuminoids, which are coagulated and settle to the bottom.

The sap should now be sufficiently clear for concentration in the usual manner. If there are reducing sugars present, which is usually the case, care should be exercised that the sap be not alkaline during the boiling period, since a dark color will likely appear, which is most undesirable in a high grade sirup.

If it is found that the sirup will have too strong a flavor when brought to the usual density, and at the same time it is not feasible to have it thin on account of the danger of fermentation, some sugar might be crystallized out of a portion and these crystals melted with the clarified juice and concentrated until the sirup is brought to the required density.

As soon as the sirup has reached this point it should be placed in clean air-tight containers and sealed at once. Such sirups should keep almost indefinitely and find a ready market.

MAPLE SIRUP.

Although this sirup can not be produced in the Philippine Islands, owing to the absence of maple trees, a brief description of its manufacture is here given for the sake of comparison with the other methods.

Maple sirup is made from the sap of the sugar maple (*Acer saccharum*) and the allied species of the same genus found growing in temperate climates. The impurities contained in this juice possess a very pleasant flavor and are in fact responsible for the sirup being considered a great delicacy. On this account a highly clarified sirup is not desired, as the distinctive flavor would then disappear, and the sirup would not be unlike any other sirup from highly clarified juices, since the sucrose contained is identical with that of the sugar cane and other saccharriferous plants.

The sap is gathered from the different trees usually twice each day, morning and evening. Where especial attention is given to cleanliness throughout the process and a high grade sirup is sought, the containers which receive the sap at the trees are made of galvanized iron and are provided with covers to exclude leaves, pieces of bark, etc.

As soon as the juice reaches the sugar house it is carefully strained through cloth and evaporated immediately. The apparatus originally used for this work of concentration was simply a series of kettles arranged in a battery, the boiling juice being dipped from one to another during the course of evaporation. In modern maple-sugar houses this work is done in copper or galvanized-iron evaporators containing compartments into which the juice flows by gravity during boiling. They are heated by steam instead of the direct flames, thus minimizing caramelization. Even with this style of evaporator extreme care is exercised in the process of condensation to prevent the sugar solution from becoming superheated, which condition would greatly impair the quality of the finished product. In the last

compartment this is especially important since the sirup has become very heavy and burns easily.

The density to which the sirup is boiled has a great deal to do with its quality and selling price. If the sirup is made too thin it is liable to ferment and spoil, while if it is made too dense it will be in danger of crystallizing after standing for some time. It is usually considered that a maple sirup with a density of 60° to 65° Brix will give the best results under ordinary circumstances.

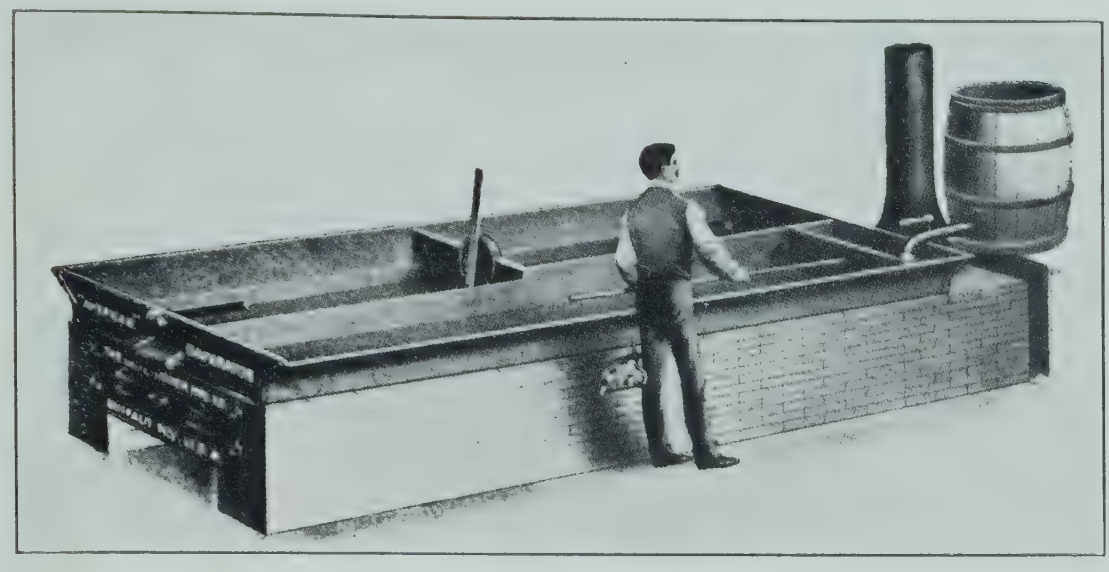
Many grades of maple sirup are on the market, all of which may be derived solely from the sap of the maple tree, yet each possesses such a distinct flavor as to lead one to conclude that some are artificial or adulterated sirups. The last sirup of the season and the sirup which has been burned during boiling, as well as those which have been made where strict cleanliness during the process was not practiced, have all an inferior flavor and color.

GLUCOSE SIRUP.

This sirup is sold under various trade names and in America is quite often called "corn sirup." The main reason for its receiving this name is that the starch from corn is extensively used in its manufacture. In Europe the starch from potatoes and rice is also used for this purpose. There is no essential difference in the sirup made from these starches, except in the details of manufacture. The principle used in the making of this sirup is to boil the starch with a powerful acid, such as sulphuric or hydrochloric, which exerts a hydrolytic effect upon the starch, splitting it up into its component parts and thus producing commercial glucose. This glucose includes several of the monose sugars and must not be confused with the chemical substance known as glucose or "dextrose" which is but one of the constituents of commercial glucose.

The amount of acid employed in the hydrolyzation of the starch depends upon the percentage of starch and impurities present. Usually, however, it will require from 1 to 3 per cent of a strong mineral acid. In recent years hydrochloric acid has been used extensively for this purpose since the precipitate which forms after the use of sulphuric acid, as formerly employed, gives the sirup a cloudy appearance unless it is entirely removed.

With many persons there is a prejudice against the glucose sirups because of the fact that glucose is an artificial or prepared



(*a*) Open-fire sirup evaporator.



(*b*) Steam-coil sirup evaporator.

This apparatus is provided with copper coils to carry the steam for heating and is arranged with a trough around the top to receive the brushings or light material rising to the top during evaporation.

compound and is largely used as an adulterant in preserves and other delicacies for the more expensive sugar sucrose. If these sirups have been properly made and no foreign matter admitted, there is no particular reason for the existence of this prejudice on the ground of their being less wholesome than other sirups.

Sucrose or cane sugar in the course of digestion is first inverted or changed into the two components of ordinary glucose. These sugars are not as sweet as sucrose and they are therefore often mixed with a more powerful substance such as sucrose and saccharine in the preparation of sirups, preserves, etc.

The ratio of the sweetness of glucose (dextrose) to sucrose is usually considered as 2 to 3. That is, it is only about two-thirds as sweet as the cane sugar. Glucose sirup itself is a clear, colorless, fluent liquid. Its density is of course determined by the amount of solids present. While it has not an unpleasant taste, at the same time it would not appeal to the palate unless given some artificial flavor. For this reason, each factory making this class of sirups usually turns out a sirup with a peculiar flavor calculated to enhance its popularity. It is often customary, although not essential, to give the sirup a unique tint or color as well.

CONCLUSION.

There are large quantities of various kinds of sirups and artificial honeys shipped into these Islands each year, all of which could be readily made from homegrown products. Cane sirups, equal to or even superior to those found in most parts of the world, could be made from the Philippine sugar cane. The high purity of the original juice makes it especially adaptable to that purpose. If glucose sirups and artificial honeys are demanded, they can be made by a combination of sucrose from the sugar cane and the hydrolyzed starch or glucose from the rice and various other plants produced in these Islands.

The sap from certain sacchariferous palms indigenous to various parts of these Islands not only contains a high percentage of sucrose but also possesses a distinctive flavor which is quite pleasant. Among these plants may be mentioned the sugar palm (*Arenga saccharifera*). If it is desired to reduce or alter the flavor of these sirups or prevent them from crystallizing upon standing, this may be done by the addition of a quantity of glucose sirup made from the starch of the same tree.

In the preparation of any article for the trade it is necessary

to have a uniform product and put it up in attractive packages. It should always have a uniform body, color, and flavor. The containers should be thoroughly sterilized and the sirup should be poured in and sealed while it is hot.

With the classes of sirups which the Philippines are able to produce and with a proper selling agency to handle such products, there is no reason why they could not become of considerable commercial importance.

CITRUS BARKROT.

By G. H. Zerbst, *Station Superintendent.*

Citrus growing in the Province of Batangas has suffered a serious setback by the appearance of a disease known as barkrot, which, becoming particularly severe after the eruption of Taal Volcano in January, 1911, has led many growers to believe that the eruption which defoliated the trees is responsible for the outbreak.

The disease occurs not only in the towns of Tanauan and Santo Tomás which are near the volcano, but over practically the entire province. Tanauan and Santo Tomás, where citrus growing is the principal vocation of the people, have suffered heavily, and, unless checked, the disease threatens to wipe out the citrus groves of these towns.

The mandarin (*Citrus nobilis* Lour) appears extremely susceptible to the disease, which apparently has much in common with the well-known "gummosis," with the exception that the disease is an exudation of sap instead of gum. The calamondin (*Citrus mitis* Blanco) is also attacked, but with much less severity. The calamondin seems to be much more susceptible to the true gummosis.

The sweet orange (*Citrus aurantium* L.) and pomelo (*Citrus decumana* L.) are much more resistant than the mandarin, being seldom attacked to a serious degree.

One fact that distinguishes this disease from gummosis is that, while young trees and seedlings are susceptible to gummosis and are frequently attacked, even in the nursery, young trees are immune to barkrot.

A characteristic of barkrot, and in this it is similar to gummosis, is that in some cases badly infected trees mature their fruit prematurely, the fruit showing a bright yellow color while still very small. This is particularly noticeable in the mandarin as this fruit usually does not color well in the Philippines.

The disease makes its presence known by the oozing out of sap from the bark which softens and forms a putrid sore. These sores vary in size from one-half to $3\frac{1}{2}$ centimeters in

diameter, and appear on the trunk and branches usually one-half to 1½ meters from the ground, although the disease occurs as high as 3 to 4 meters on the larger branches. Where the disease is severe these spots occur thickly and finally unite, with the result that the tree or branch is quickly and effectively girdled. Numbers of insects are attracted to the sores by the putrid sap, and the spots are usually found to be infested with the larvæ of various insects which aggravate and keep up the irritation, preventing the healing of the wound. As the tree strives to overcome the disease, the spots dry up, the edges of the sores begin to heal over, and the bark curls or scales, giving the branch or trunk an unsightly appearance. On brushing off the dead bark, the new wood is seen forming on the edges of the sores, giving to badly affected branches a queer distorted appearance.

The term barkot is to a certain extent misleading as the disease does not originate in the bark. If the bark and cambium layer are cut away and the underlying wood carefully examined, a dark-colored area, usually of a brown to reddish tinge, is found. This extends into the wood, varying in depth in different cases. As in gummosis, the sap collects in pockets between the wood and cambium layer until the bark is separated from the wood and finally split by the pressure within, so that the sap oozes out.

The Bureau of Science has carried on investigations with barkrot but has failed to find a bacterium to which the disease might be attributed.

Gummosis is, by various writers, attributed to excessively deep setting of trees when planted, or to the accumulation of earth about the trunk of the tree by cultivation. Barkrot, however, makes its appearance on trees whose crown roots are totally exposed.

Barkrot is not a disease that can be quickly cured by drastic measures, but one that necessitates the most persistent and intelligently directed efforts. To simply cut out the diseased area is useless, because the causal factors still remain. The removal of the effect without the elimination of the cause is a waste of time and money.

Apparently barkrot is a physiological disease produced by unfavorable soil and cultural conditions, and this is strikingly proven by the comparison of neglected groves with those that receive proper care and attention. Lack of cultivation is one of the main causal factors of other disease. In groves that receive no cultivation, the ground becomes hard and packed, and

in groves where cattle are also allowed to range, the earth speedily becomes nearly as hard as a cement floor. This packing of the soil prevents drainage and aeration, a condition that, needless to say, is fatal to citrus trees. Irregularity of the water supply is also a factor, and this can be controlled by proper culture and mulching.

Proper plowing and cultivation, varying in depth each year, and the planting of leguminous cover crops during the rainy season, are apparently essential in the prevention and cure of barkrot. The cover crop should be cut and left as a mulch during the dry season.

The treatment of the tree itself is a matter of secondary importance. The earth around the trees should be thoroughly loosened and stirred with a pick or mattock. The diseased spots should be carefully cut out with a sharp knife, and in doing this the cut should be made down to the healthy wood. The wounds should at once be painted with some protective material such as white lead paint; some writers recommend a mixture of wax, resin and oil.

The work being carried on by the Bureau of Agriculture along the above lines has proven satisfactory and the decided improvement of infected groves, under the treatment given, leaves little to be desired.

"DAPOG" METHOD OF RICE CULTURE.

By Silverio Apostol, *Agricultural Inspector.*

The custom of growing two crops of rice per year has been practiced for a long time in those parts of the Philippines where sufficient irrigation water is available the year round. In certain sections of the Provinces of Tarlac, Pampanga and Laguna, for instance, preparations for a second or dry-season planting are made shortly after the first or regular-season crop is harvested. Naturally the earliest of the lowland or irrigated rices are used for this purpose for two apparent reasons: first, in order to be able to gather the harvest before the rainy season has well started, and second, to allow ample time to prepare the land for the main crop.

Direct culture, in which the seed is sown broadcast by hand on the permanent field after the soil has been puddled and leveled, is the only method employed in growing the second crop in all these places except the municipality of Calauan and a small part of Bay, Laguna. In these latter localities the crop is started and transplanted by means of a method of seed bedding or growing the seedlings locally known as "dapog."

The dapog system enables the seedlings to be transplanted at a younger age than those grown in the ordinary way of seed bedding, without breaking the young plants when removing them from the seed bed. Earliness is of primary consideration in the dry-season crop, so that transplanting *young* seedlings is an essential condition sought for in the dapog method, as the age of the seedlings directly affects the maturing period of the rice crop. The older the seedlings are when transplanted, the later will the crop mature. In this connection it might be stated that the writer has observed from actual experiments a difference of as many as 23 days in maturing, between crops planted with dapog and with ordinary seedlings.

The preliminary preparation of the seed beds under the dapog system begins with that of the permanent field, as in this system the seed beds do not require any special ground. In the absence of rain, the field is irrigated, drained of excessive surface water, and then plowed and harrowed or otherwise prepared as for

a regular-season crop. When the ground is fairly well worked up, a plot near the irrigation ditch is further harrowed and then leveled for the seed bed. Proximity to the irrigation or inlet ditch is a necessary requirement because the water is not likely to become so hot there as elsewhere at midday and to scald or otherwise seriously affect the germinating seeds.

It takes from 15 to 30 liters more seed to plant one hectare by the dapog than by the ordinary method. The seed, placed in a burlap sack or similar receptacle, is first soaked in water (preferably slow running) for a period of 24 to 36 hours, and then removed and laid aside in the shade. At the end of another 36 hours, or when at least 75 per cent of the grains have shown signs of germination, the seed is sown on a seed bed prepared as follows:

That part of the paddy where the seedlings are to be grown is, as mentioned above, further harrowed on the same day that the seed is sown, and once leveled and the mud settled, the surface water is drawn off. Fresh, unbroken banana leaves, squared at the ends and cut lengthwise through the midrib are then laid flat on the thick mud so as to form beds about one meter wide and nearly as long as the width of the paddy. These leaves are placed with their peripheral edges toward the center of the bed, the split midribs thus forming a raised outer border. The ends of the long narrow beds so formed are closed with similar split leaves placed crosswise. The rounded extremities of the leaves used are cut off to facilitate fitting. Since one banana leaf split will rarely cover a meter in width, the two sections are drawn apart so that the split midribs will be flush with the edges of the bed and the peripheral edges will not meet in the center; the intervening space left in the center of the bed is covered with plain leaves from which the midribs have been completely removed so as to leave no ground exposed. If the leaf strips are badly torn, these tears should be covered with loose pieces of leaves. In fact, it is better to cover the entire bed with two or three thicknesses of leaves.

With the banana-leaf mat properly laid the bed is completed by covering it with a layer of either clean rice chaff or finely chopped rice straw to a depth of two or two and a half centimeters. A thick sowing of the sprouted seed is then carefully made on this surface. Seventy-five liters of seed are sufficient for seeding two dapog beds, each measuring fifteen meters in length and one meter in width. It is better to sow the seed in the afternoon and it should then be carefully and thoroughly sprinkled with the muddy water from around the beds.

In those months when the rays of the sun are intense, especially between ten o'oclock in the morning and two or three in the afternoon, it is generally necessary to build a light screen about 30 or 40 centimeters above the beds so as to protect the growing seedlings from the excessive heat. This screen can be made of banana leaves placed on a light frame of bamboo sticks and slats. More necessary and more important than shade, however, is a proper supply of water, and much care and attention should be exercised in watering the seed beds, especially during the first few days after sowing. This watering should be done several times during the day, and regular garden sprinkling cans have been used to great advantage by the writer in connection with his own work. Later, when the young plants are no longer in danger of being washed away, they should be irrigated with slow-running water until transplanting time, as standing water during a hot day is apt to seriously affect the young seedlings. While care should always be exercised in watering so as not to submerge and drown the young plants, the seed bed should nevertheless not be allowed to run dry for any considerable length of time at any stage of the young plants' growth, or else the seedlings would be fatally injured, especially if there is no shade during the heated part of the day. The rice chaff or the finely chopped straw, whichever is used, is practically the only medium in which the plants so seeded can grow, as they are, of course, deprived of the soil moisture by the underlying mat of banana leaves which, in a sense, forms a "hard pan" which their tender roots can not penetrate.

The dapog method of seeding, therefore, makes it possible to transplant seedlings at a much younger age than the ordinary method without at all straining or breaking them when removing them from the seed bed. The heavy rate of seeding is necessary in order to give the young seedlings, growing on such a light and loose medium, a firmer stand. The banana-leaf mat underneath naturally makes the roots run laterally rather than downward, and thus the roots of the neighboring plants soon interweave, and the seedlings are kept in an erect position. The entire bed is thus a long, narrow, carpet-like sheet of young plants, which can be easily lifted and removed from the underlying banana leaves. At transplanting, the "carpet" or "mat" of seedlings is torn into strips of convenient size, hung across the arms and shoulders, and carried to the field. Small strips may also be loosely rolled up with the foliage inside and transported to more distant points. In this

case the rolls should be undone immediately upon arriving at destination. Here the strips are further torn into pieces about the size of a small plate and scattered over the paddies in the same manner as the bundles of ordinary seedlings. These small pieces are picked up by the transplanters as they proceed with their work, held flat on the palm of the left hand by the left thumb, and then a few of the young seedlings at a time are pulled off by the thumb and the first two fingers of the right hand and stuck into the mud to make the hills.

The final harrowing and puddling of the field is done on the same day as the transplanting, or part of it may be done the day before. The dapog seedlings are ready to be transplanted from ten to fourteen days after the seed was placed in water. It is the experience of the writer that when the young plants are in good condition and properly handled, transplanting at the rate of from three to four seedlings to the hill and at the usual distance of from fifteen to twenty centimeters is sufficient to insure an even stand and a maximum yield under ordinary circumstances. The average rate of transplanting in common practice is higher. If transplanted when more than twelve days old, the dapog seedlings are greatly weakened, owing to the heavy rate of seeding and the nature of the seed bed, and consequently a larger death rate occurs. The ground on which the seed bed is located is not materially affected, and, once the seedlings are all removed, the banana leaves can either be taken up or harrowed under, and the entire paddy planted. If the seedlings have for any reason grown very tall, the upper portion of the foliage should be trimmed off before they are transplanted.

Recommendations.—Ordinarily, irrigated or lowland rice gives a heavier yield when it is transplanted than when grown direct by broadcasting the seed, and the writer strongly recommends at least the trial of the "dapog" method by those who have not as yet done so, especially with their dry-season crop. A beginning can be made by planting a small portion of the field by the dapog method side by side with a broadcasted lot, letting the results speak for themselves. The system was tried by some farmers of Santa Rosa, Laguna, some years ago, and, despite the extra expense incurred in transplanting, it has been gaining favor among the rice growers of that municipality ever since its introduction, gradually taking the place of the broadcasting method. In Calauan and Bay the dapog is the only method practiced at present for short or dry season rice, in preference to broadcasting, which was abandoned some time ago. The

writer has had very encouraging results in his own work at Calauan with the dapog system. The principal drawbacks with broadcasting are the necessity of special care in leveling the paddies and in the subsequent irrigating of the germinating plants therein, the impossibility of sowing evenly by hand and the consequent waste of seed, the impracticability of weeding, and, as a whole, the more uncertain results that generally go with broadcasting under ordinary circumstances. The rate of sowing is usually heavy so as to allow for the probable failure of many plants to reach maturity; however, if, on account of favorable conditions, only a small percentage of the plants fail before heading time, the remaining plants and their heads are consequently abnormally undersized and defective, and these conditions are to a great extent at least overcome by the dapog system. In other words, conditions are under better control with the dapog than with the broadcasting method. Of course, one of the principal factors that will determine the profitableness of the dapog method is the amount and cost of the available labor supply in a given locality. At any rate, second or dry season growing, whether by the dapog or by the broadcasting method, should never be attempted unless there is sufficient irrigation water available whenever needed during the growth of the crop. The dapog system can also be practiced in growing early lowland-rice varieties during the regular season.

NEW OR NOTEWORTHY TROPICAL FRUITS IN THE PHILIPPINES.[1]

By P. J. WESTER, *Horticulturist in Charge of Lamao Experiment Station.*

When there are taken into consideration the modern facilities for travel, the rapidly growing intercommunication between even the remote corners of the earth and the rapid exchange of news through periodicals or correspondence from all parts of the world that characterize modern life, the temptation is frequently great to think that the localization of useful economics would almost be a thing of the past, and that food plants especially would soon be distributed to all parts of the world where the climatic conditions are favorable for their development. Yet, when the multitude of useful plants is considered as well as the extent of the geographical area in which they are or might be cultivated, and how comparatively few plants there really are that may justly lay claim to be truly cosmopolitan, one realizes how much plant introduction and distribution work there still remains to be accomplished. This refers in a peculiar degree to tropical fruits and particularly to those of the Philippines.

Every one conversant with the subject is well aware that some fruits are scarcely known outside of the countries to which they are native and the cultivation of still others can hardly be said to have begun even in those countries where they are indigenous.

This limited distribution is largely due to the non-keeping quality of the seed of so many tropical fruits, but with the rapidly expanding intercommunication and quick transportation between all parts of the world, and a better knowledge of the packing of seeds and plants so as to insure their safe arrival at the point of destination, there should soon be little if any excuse left for any part of the globe that does not grow those useful plants to which it is heir by reason of climatic adaptation. In the following paragraphs attention is called to a few species of fruit trees that are comparatively little known in the West-

[1] For other papers of a similar nature consult this REVIEW, Vol. V (1912), No. 11, p. 593, and Vol. VI (1913), No. 10, p. 493.

ern Hemisphere, and to others which are apparently new to horticulture or not well known even in the Far East outside of the Philippines:

BIGNAY, *Antidesma bunius* Spreng. EUPHORBIACEÆ. (Plate VI, *a*.) An attractive, dicœcious tree, attaining a height of 4 to 10 meters; leaves alternate, 10 to 20 centimeters long, oblong ovate to elliptic or obovate, acute, or shortly acuminate, entire, shining; flowers small and inconspicuous, produced in axillary or terminal racemes—the male being reddish, and the female green—exhaling a pungent odor; fruits growing 20 to 25 or more on a raceme; individual fruit rather small, averaging 3 grams in weight, and 8 to 10 millimeters in length, spherical to ovoid, dark red; flesh juicy and pleasantly flavored.

Eighty per cent of the fruit is edible and the acidity 2.78 per cent.[2]

The fruit makes an attractively colored, red jelly, but this, in the several experiences of the writer, unfortunately has a very unpleasant aftertaste. If by some simple expedient this can be removed, the bignay would be excellent for preserves.

The bignay is of vigorous growth and very productive, with the main fruiting season in July and August. The tree is indigenous to Malaysia and is common in the Philippines.

CATMON, *Dillenia Philippinensis* Rolfe. DILLENIACEÆ. (Plate VII, *a*.) An ornamental tree, 6 to 15 meters tall; leaves dark green, 12 to 25 centimeters long, ovate to elliptic, or oblong ovate, coarsely serrate; flowers terminal, large and attractive, white, occasionally exceeding 12 centimeters in diameter; fruit averaging 60 to 65 grams in weight, 46 millimeters in length and 57 millimeters in width, globose to oblate, smooth; the persistent sepals grow large and somewhat fleshy, enclosing the fleshy, edible carpels, which wind spirally around the center of the fruit; flesh greenish, quite juicy and acid and containing a few small seeds or none at all.

Thirty-eight per cent of the fruit is edible; the protein content is 0.25 of 1 per cent and the acidity 1.52 per cent.

The fruit is too sour to eat out of hand, but makes an excellent sauce and would probably make a good jelly.

The catmon is indigenous and common throughout most provinces of the Philippines, but is seldom cultivated and is hardly ever seen abroad, even in botanical gardens. It makes a very good shade tree and endures close trimming of the crown better than most tropical shade trees. The fruit of the catmon as well as of the kambog, *Dillenia speciosa*, is greatly superior to that of the better-known *Dillenia indica*.

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[2] The analytical data in this article, except where otherwise stated, have been obtained from "Philippine Fruits: Their Composition and Characteristics" by D. S. Pratt and J. I. del Rosario, Philippine Journal of Science, Vol. VIII (1913), Sec. A, No. 1.

LANZONE, *Lansium domesticum* Jack. MELIACEÆ. (Plates VI, *b*, IX, *a*. See also this REVIEW, Vol. V (1912), No. 11, Plate II.) A handsome, symmetrical tree, attaining a height of 4 to 10 meters; leaves alternate, pinnate, 20 to 40 centimeters long, leaflets 5 to 7, oblong, acuminate, 8 to 18 centimeters long; flowers small, and borne on spikes from the trunk and larger branches; fruits growing 20 to 30, in grapelike bunches each weighing 375 to 450 grams; individual fruits comparatively small, being 30 to 40 millimeters long, 24 to 30 millimeters in equatorial diameter and averaging 17 grams in weight; form broadly ellipsoid to oblong ovoid; surface velvety; color dull straw; skin rather thick, tough, separating readily from the flesh; edible portion consists of 5 locules, separable from each other by a thin membrane; flesh whitish or translucent, tender, juicy, sweet, subacid, well flavored and of good quality; seeds 1 to 3, rather large, not infrequently absent, adhering to flesh.

Seventy-seven per cent of the fruit is edible, containing 1.13 per cent protein, 4.9 per cent sugar and 1 per cent acid.

The ripening season of the lanzone varies, in different localities, from August to late in November and even later. The writer has seen trees in bloom in the middle of August, in the interior of Mindanao, at an elevation of 810 meters, and sampled ripe fruit 4 days later in Zamboanga, at sea level.

The lanzone is of vigorous growth and succeeds best under somewhat the same climatic conditions as the mangosteen. It will not grow where there is a pronounced and prolonged dry season, and in the Philippines it is usually grown in half shade interplanted with the coconut.

The lanzone is extensively grown for the Manila market in Laguna Province, east of Santa Cruz, and is also cultivated to a considerable extent in Misamis, Zamboanga, the Sulu Archipelago, and around Argao in Cebu. In certain towns of Bukidnon and around Lake Lanao in Mindanao the lanzone is quite largely grown, but the fruit there is inferior to that produced at sea level, and it is evidently essentially a lowland fruit.

The lanzone is indigenous to Malaysia, and has barely been introduced beyond the Eastern Hemisphere.

LIPOTI, *Eugenia curranii* Robinson. MYRTACEÆ. (Plate VI, *c*.) A tree attaining a height of 9 meters or more, with gnarled trunk and tortuous branches; young growth quadrangulate, alate; leaves opposite, almost sessile, oblong-obovate, auriculate, acuminate, entire, leathery, dark green and shining; fruits congregated, 20 to 50 or more, in clusters on the bare branches or between the leaves on the more mature twigs; individual fruit small, averaging 3.35 grams in weight, globose, with cavity 3 millimeters deep; surface smooth, dark red, changing to black at full maturity; skin very thin; flesh red near skin, otherwise white, rather dry and crisp, pronouncedly acid with a pleasant flavor not unlike that of the crab apple; seed relatively large, clinging to flesh, sometimes absent.

The lipoti is too acid for a dessert fruit, but like its near relative, the duhat, *Eugenia jambolana* Lam., it would, in all probability, make an excellent jelly.

The lipoti is of vigorous growth, succeeds well where the wet and the dry seasons are strongly accentuated, and requires well-drained land for the best results. In productiveness it is exceeded by no other species in the genus that has come to the notice of the writer and ripens principally from April to June.

The municipal president of Bacon, Sorsogon, states in a letter to the Bureau that there are two varieties of lipoti ("Igot" or "Baligang," as the species is called in that province), black and white, and that the seedlings bear fruit 3 to 4 years from seed. According to him, the fruit is used in that locality for making preserves, wine and pickles.

Botanically as well as horticulturally the lipoti is a new fruit and is also in all probability indigenous to the Philippines. It was first collected by the writer in April, 1911, under the name of "Igot" in Catbalogan, Samar, and was described and named by the late C. B. Robinson, economic botanist, Bureau of Science, the following year. Fruits of the lipoti have been received by the Bureau from Laguna, Samar, Sorsogon and La Union, and it probably occurs in several other provinces. It is seldom cultivated.

The fruits illustrated on Plate VI, *c* were presented by Mr. José Rivera of this Bureau.

MABOLO, *Diospyros discolor* Wild. EBENACEÆ. (Plate VII, *b*.) A medium-sized tree, 8 to 15 meters high; leaves oblong, acute or abruptly acuminate, 10 to 25 centimeters long, entire, smooth and shining above and pubescent beneath; flowers axillary, small; the fruit measures 65 to 75 millimeters in longitudinal and 80 to 90 millimeters in transverse diameter, and averages 375 grams in weight, of which 73 per cent is edible, form roundish oblate with stem inserted in a conspicuous cavity; calyx persistent; surface smooth, velvety; color dull reddish; skin thin, adhering to flesh; flesh whitish, firm, rather dry, sweet, rather astringent, with a strong aromatic, cheesy odor that in a fruit is rather discouraging to the average European; flavor rather indefinite; seeds quite large, usually 4 to 8, adhering to flesh.

The mabolo analyzes 0.75 of 1 per cent protein, 6.9 per cent sugar, and 0.16 of 1 per cent acid.

There is also a variety (rarer than the red) with yellowish to light-brown fruits, the flesh of which is cream colored and sweeter, and less astringent. Trees bearing regular crops of seedless fruits are known in the Philippines.

The main season of the mabolo extends from June to September, but scattered fruits are found at practically all seasons of

the year. It is of medium vigorous growth and makes a desirable ornamental shade tree. It is indigenous to the Philippines and is fairly well introduced throughout the eastern Tropics. In the Western Hemisphere it is rarely found outside of botanical gardens.

The mabolo is a favorite with the native inhabitants, but hardly ever eaten by the European. Its chief value would seem to be in possibly crossing it with the kaki, imparting the flavor of the kaki to the hybrid fruit, while the mabolo might impart adaptability to the Tropics.

MANGOSTEEN, *Garcinia mangostana* L. GUTTIFERÆ. (Plate VII, *c*.) A small tree, 6 to 7.5 meters tall; leaves opposite, 15 to 23 centimeters long and 9 to 13 centimeters broad, oblong elliptical to oblong ovate, abruptly acuminate, thick and leathery with prominent midrib; fruit comparatively small, weighing 75 to 100 grams, seldom exceeding the latter figure, and averaging 6 centimeters in diameter; form spherical to a trifle flattened; calyx large, persistent; surface smooth; color reddish or purplish; bloom bluish; edible portion of fruit contained in the hard, shell-like, 8-millimeters-thick pericarp, which is pinkish inside and separates perfectly from the flesh; edible part of the fruit consists of 6 snow-white segments, each containing a seed or undeveloped embryo, a fruit seldom having more than two seeds; pulp juicy and tender but not melting, subacid, exquisitely flavored and faintly aromatic; seed enveloped in weak fibers extending into the flesh.

Twenty-nine per cent of the fruit is edible, analysing 0.5 of 1 per cent protein, 4.2 per cent sugar, and 0.49 of 1 per cent acid.

No one will deny the excellent flavor and quality of the mangosteen, but it is safe to say that its elevation by some old travelers to a par with the pineapple and the cherimoya as one of the three best fruits in the world—together with its restricted localization, the difficulty of its propagation and introduction into foreign countries and extremely slow growth—has done much toward making it famous. It is questionable whether it is really on a par with a first-class pineapple, and it is believed that the great bulk of people would prefer a well-grown carabao mango, as grown in the Philippines, to a mangosteen.

The mangosteen is of slow growth, and succeeds best in rich, loamy, moist but well-drained land. An even, warm climate with constant humidity, and a fairly abundant rainfall evenly distributed throughout the year, are practically indispensable for the successful culture of the mangosteen, and this, together with its slow growth and the short viability of the seeds, is accountable for its slow dissemination from its native home.

For these climatic reasons the culture of the mangosteen is

consequently probably excluded from the major part of the Tropics, and for the same reasons the area suitable for this fruit in the Philippines is rather restricted. Yet there is ample territory here where the mangosteen would succeed in supplying the home demand and leave a handsome surplus for export to Hongkong, China, and Japan. The lanzone district of Laguna and the protected valleys of Tayabas, Albay, Ambos Camarines, Sorsogon, northern Samar, Butuan and Davao are suggested as suitable for the mangosteen. At present the mangosteen is confined to the Sulu Archipelago, except perhaps two dozen trees on the north and west coast of Mindanao, some three or more trees in southern Negros and one in Porac, Pampanga. Nearly all the mangosteen trees in Mindanao are found in Dapitan, where they were introduced together with many other fruits by José Rizal during his banishment there under the Spanish régime. The 50-year-old tree in Dumaguete, Occidental Negros, and younger trees in Misamis and Oroquieta seen by the writer, are indubitable evidence that the mangosteen may be successfully grown in those localities. Yet the annual supply sold in Manila is mostly imported from Singapore and Saigon.

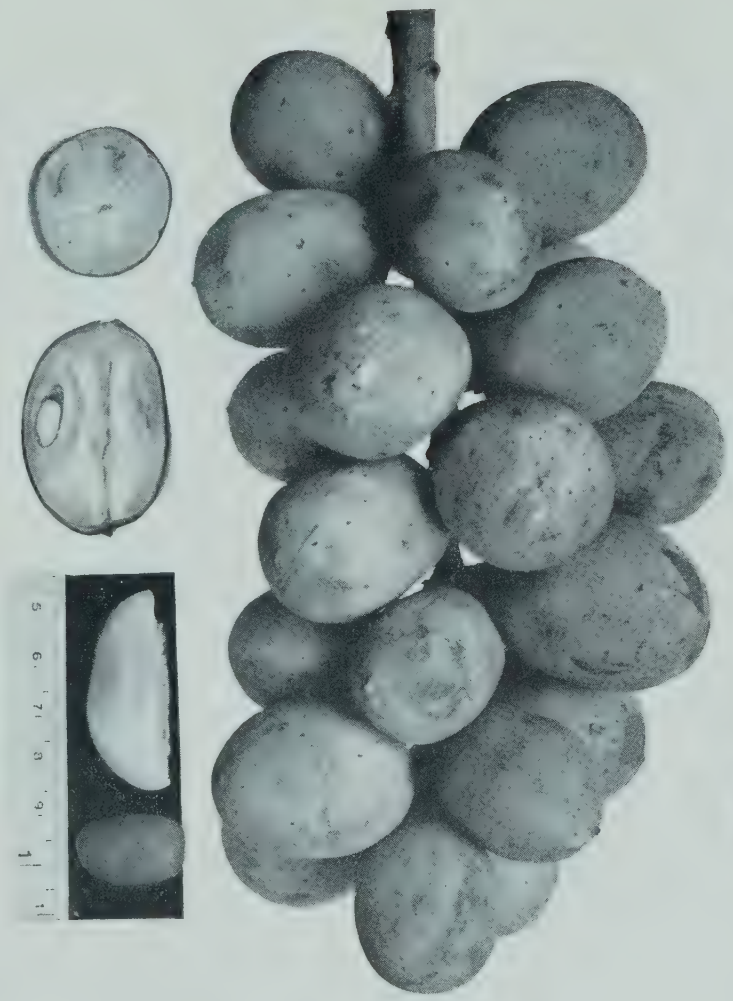
Among the better known trees perhaps no species has been so slow of dissemination as the mangosteen. It was already well known and described by Linné, yet 100 years elapsed before the first tree fruited in the American Tropics in Trinidad. A few trees have since fruited in Jamaica and Hawaii, and only last year did the first tree fruit in Queensland, Australia. This fruit has scarcely found its way beyond the botanical gardens except in the East.

Mangosteen culture would no doubt be considerably furthered if a congenial, vigorous stock could be found, but the more substantial hope for the future is unquestionably the hybridization of the mangosteen with some of its numerous relatives.

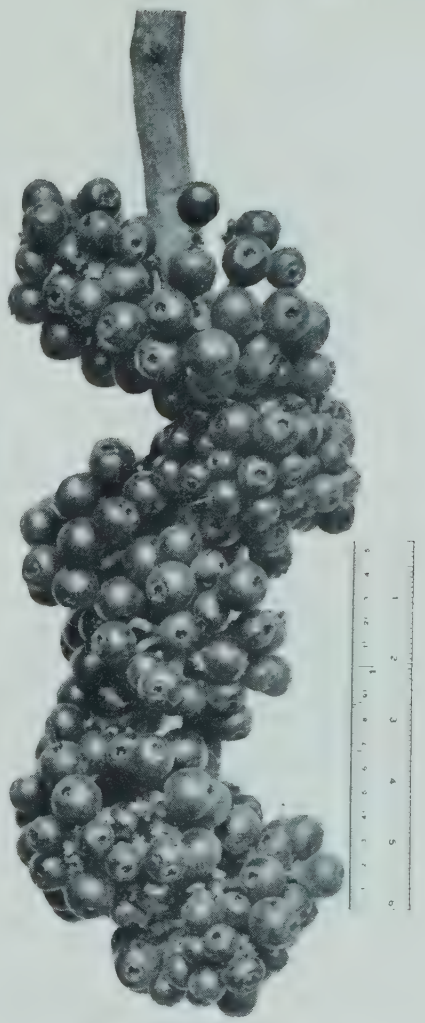
MARANG, *Artocarpus odoratissima* Blanco. URTICACEÆ. (Plates VII, *d*, IX, *b*.) A tree of medium size, similar in habit to the bread fruit; leaves large, dark green, 45 to 60 centimeters long, and 25 to 30 centimeters broad, entire, or more or less trilobate; fruit very large, averaging 16 centimeters in length, and 13 centimeters in transverse diameter, and attaining a weight of 1,000 to sometimes exceeding 1,800 grams, roundish oblong, regular, thickly studded with soft, greenish yellow spines, about 7 millimeters long on the outside; rind thick and fleshy; flesh white, very sweet and rich, juicy, very aromatic and of excellent flavor, separated into segments (about the size of a grape) clinging to the core, each segment containing a seed; seeds many, whitish, 8 by 15 millimeters, smooth, separating readily from the flesh.



(*a*) Bignay (*Antidesma bunius*).



(*b*) Lanzone (*Lansium domesticum*).



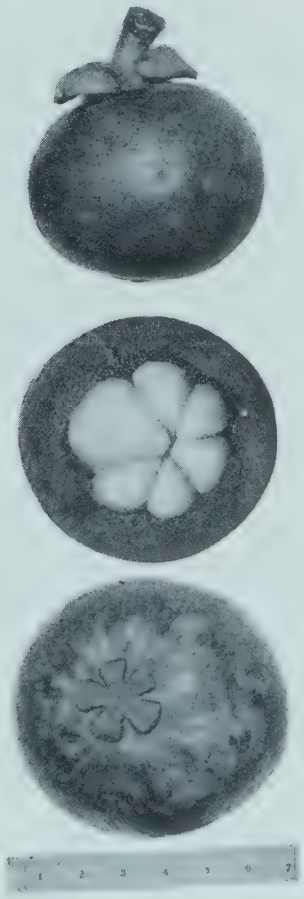
(*c*) Lipoti (*Eugenia curranii*).



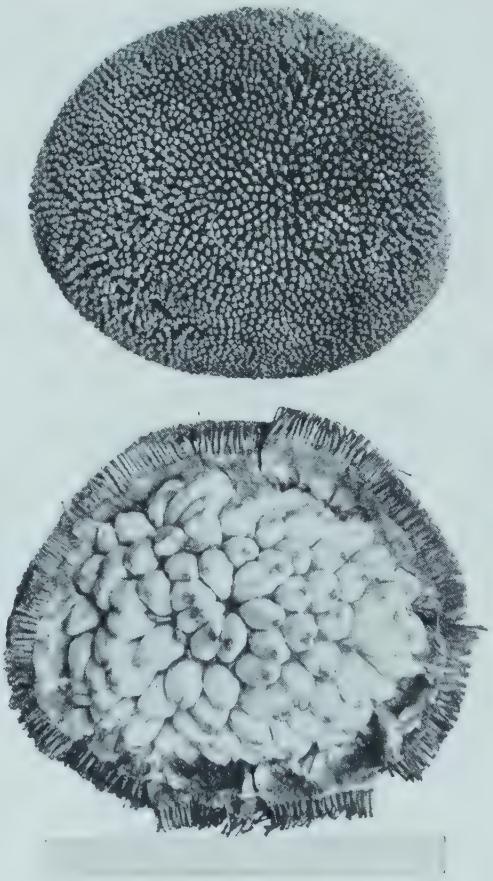
(*a*) Catmon (*Dillenia philippinensis*).



(*b*) Mabolo (*Diospyros discolor*).



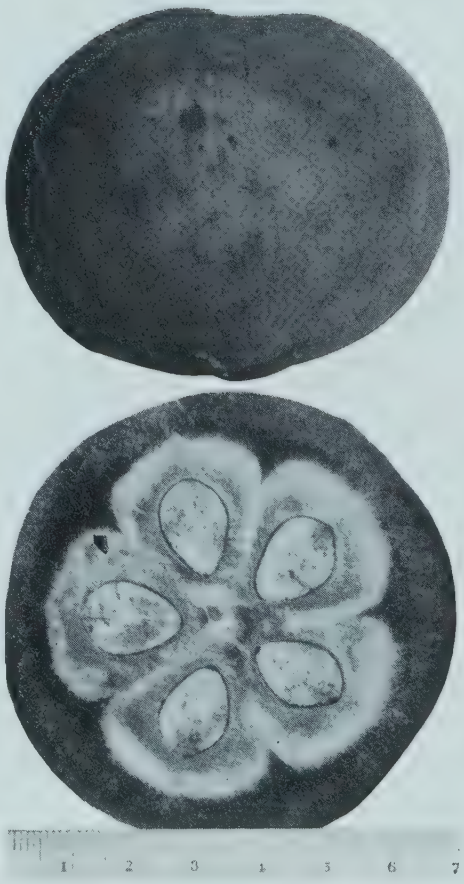
(*c*) Mangosteen (*Garcinia mangostana*).



(*d*) Marang (*Artocarpus odoratissima*).



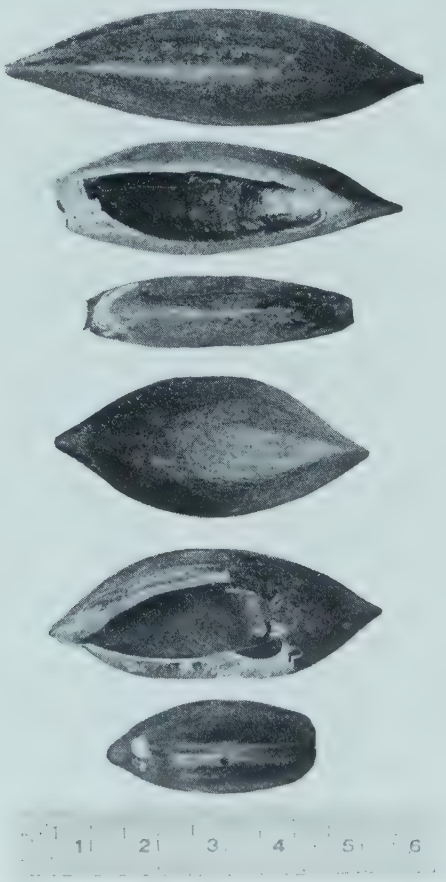
(*a*) Gomihan (*Artocarpus elastica*).



(*b*) Santol (*Sandoricum koetjape*).



(*c*) Baniti (*Garcinia dulcis*).

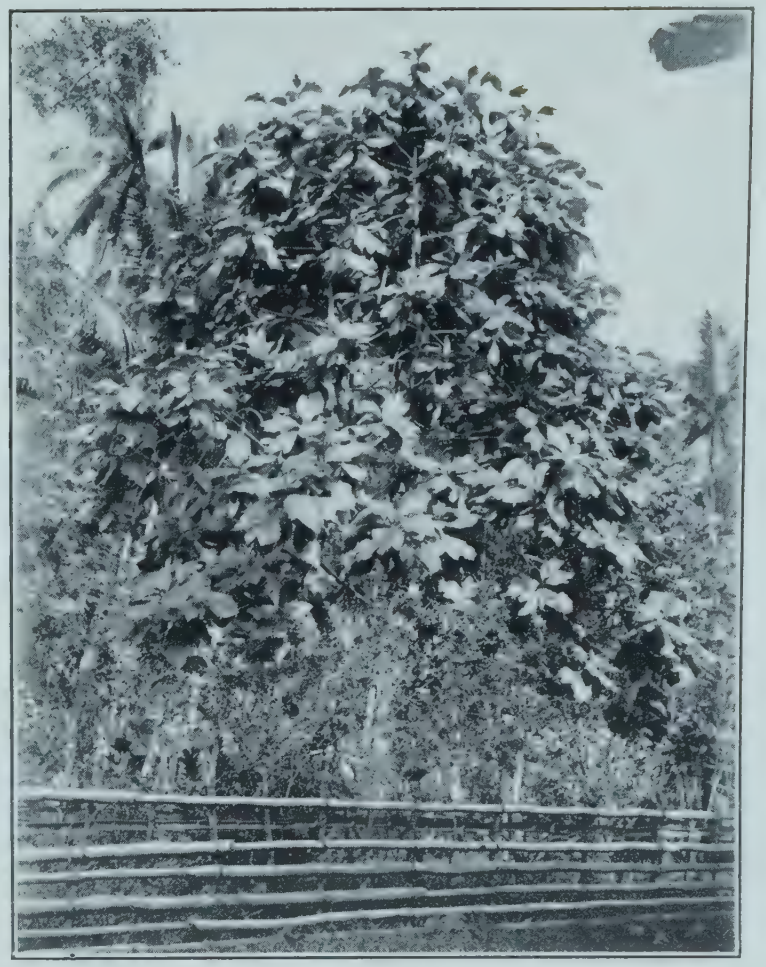


(*d*) Pili nuts (*Canarium ovatum*).

The three topmost are the long type; the three lower the short, broad type.



(*a*) Lanzone tree (*Lansium domesticum*).



(*b*) Marang tree (*Artocarpus odoratissima*).

By passing a knife around and through the rind of the mature fruit, with a little care, the two halves of the rind separate from the flesh, leaving this adhering to the core not unlike a bunch of white grapes.

Of a fruit examined by the writer, weighing 1,080 grams, the rind weighed 615 grams, the core 130 grams, the seeds (100 in number) 85 grams, and the flesh 250 grams, the edible portion of the fruit being 24 per cent of the total weight.

The marang is very rich in carbohydrates and in flavor is not unlike the sugar apple, which, however, it greatly surpasses in richness. As a dessert fruit it is far superior to the jak and related species in the Philippines, and will undoubtedly attain prominence among the tropical fruits when it becomes better known.

July and August is the main season for the marang, which is found in the Sulu Archipelago, on the south coast of Mindanao from Zamboanga to Davao, in the interior of that island at Lake Lanao, and in the Islands of Basilan and Mindoro.

The marang thrives under climatic and soil conditions similar to those enjoyed by the mangosteen and the lanzone, and is usually grown in partial shelter, interplanted with taller trees such as the coconut. Considering how fond the Filipinos are of the marang it is most surprising that this fruit has not become more widely dispersed in the Archipelago.

GOMIHAN, *Artocarpus elastica* Reinw. URTICACEÆ. (Plate VIII, *a*.) A tree of medium size, sometimes exceeding a height of 15 meters, with the habit of the bread fruit; leaves 35 sometimes exceeding 50 centimeters in length and 32 centimeters in width, entire or with three or more large lobes, dark green, rather rough and hairy beneath; fruit spherical, 9 rarely exceeding 11 centimeters in diameter, orange-yellow, covered with threadlike, hairy, rather coarse, more or less twisted filaments 35 millimeters long, skin thick, separating readily from the flesh like the marang; flesh watery, white, sweet, juicy, somewhat aromatic and of fair to good quality; seeds many, small, separating readily from the flesh.

The gomihan is probably more closely related to the marang than any other species in the genus, and resembles it in structure, texture and flavor, though greatly inferior to the marang pomologically.

The gomihan has been noted in Ambos Camarines, Albay, Sorsogon, Tayabas, Samar, Masbate, Biliran, Surigao, Agusan and Mindoro and probably extends to most islands in the Philippines. The tree is rarely cultivated, and the fruit, ripening from May to July, is but little esteemed. The seeds, roasted and eaten like peanuts, are of fair quality.

The gomihan was first called to the attention of the writer by Mr. E. E. Schneider, Bureau of Forestry.

SANTOL, *Sandoricum koetjape* (Burm.) Merr. MELIACEÆ. (Plate VIII, *b*.) A medium sized tree attaining a height of 15 meters; young growth pubescent; leaves trifoliolate, leaflets 10 to 15 centimeters long, elliptic to oblong ovate, acuminate; flowers numerous, greenish yellow, in axillary panicles 10 to 20 centimeters long; the fruit averages 4 to 5 centimeters in length, 5 to 6 centimeters in equatorial diameter, and weighs 100 to in good varieties exceeding 150 grams; form roundish oblate to oblate; stem stout, inserted in a shallow cavity; surface velvety; color brownish yellow; rind 6 to 14 millimeters thick, tough and leathery; pulp in five sections, separable from the rind, whitish to translucent, rather fibrous (fiber fine), juicy, subacid, aromatic, in good varieties spicy, vinous and of excellent flavor; seeds 5, large, embedded in the pulp, clingstone.

The edible part analyzes 0.86 of 1 per cent protein, 3.08 per cent sugar, and 1.35 per cent acid.

Indigenous to Malaysia, the santol is one of the most widely distributed fruits in the Philippines. The tree is hardy, of vigorous and rapid growth, and succeeds well even where the dry season is prolonged. The fruit is produced in great abundance, in fact in such profusion that large quantities annually rot on the ground during the ripening season which extends principally from July to October. It should be stated that the waste of the fruit is due chiefly to its poor quality, in fact, from the European point of view most of the santols are barely edible. However, now and then trees are found whose fruit is of most excellent flavor, and when a fruit shall have been found that also has the feature of being seedless or semi-seedless like the mangosteen, it is believed that the now practically unknown santol will become one of the most popular of the tropical fruits. The santol can be utilized in making a jelly and marmalade of very distinct flavor and of excellent quality.

BANITI, *Garcinia dulcis* Kurz. GUTTIFERÆ. (Plate VIII, *c*.) An evergreen tree, 7.5 to 9 meters tall; leaves opposite, 15 to 24 centimeters long, 5.5 to 9 centimeters broad, oblong, undulate, thick and leathery; base acute; apex abruptly acuminate; flowers several in axillary clusters; fruit more or less irregular in outline, from sub-globose-turbinate to sometimes flattened, the shape depending largely upon the development of one or more seed embryos, 5.5 to 6.5 centimeters long, and 5 to 7 centimeters in transverse diameter, averaging 132 grams in weight; stem, with usually 5 persistent sepals, inserted in a shallow basal cavity; apex pointed; surface smooth; color lemon-yellow; skin very thin; flesh deep lemon-yellow, juicy, melting, very similar in texture to a good mango except in having even less fiber and being juicier; very acid; seeds usually 2, rarely exceeding 3, 34 millimeters long, resembling in appearance a large bean, clingstone.

The flesh constitutes 91.55 per cent and the seed 8.45 per cent of the fruit.

According to Dr. H. C. Brill, assistant chemist, Bureau of Science, the analysis of the pulp of the baniti is as follows:

Moisture		84.42
Insoluble solids	6.78	
Protein (N x 6.25)	0.82	
Invert Sugar	2.64	
Acidity (citric acid)	3.61	
Ash	1.73	
Total solids		15.58

A striking feature of the fruit of the baniti, considering that it is absolutely unimproved and is found only in its natural wild state, is the excellent texture of the flesh, the absence of fiber, and the exceptionally great proportion of edible pulp; furthermore, the flesh is attractively colored. The one great defect which in its present state of development precludes its use as a dessert fruit uncooked is its lack of sugar and its extreme acidity. Undoubtedly it would make an excellent preserve.

The baniti is found from northern Luzon to the Visayas, Mindanao and Palawan under varying climatic conditions, and is in fact one of the most widely distributed species of the genus in the Philippines.

So far as known the baniti has heretofore never been cultivated and is rare even in the botanical gardens of the eastern Tropics; its pomological possibilities seem hitherto to have been overlooked. The writer's attention was first called to the baniti by Mr. A. W. Prautch, of Manila, who submitted a number of well-known fruits, collected in Antipolo, Rizal; according to him sweet-fruit trees are found in the same province. As a matter of fact the specific name of the plant indicates that it was described and named from specimens of such a variety.

The tree is prolific and the fruit ripens from February to May.

The greater range of climatic adaptability and the robust character of the baniti suggest that, if the two species are sufficiently congenial, it might be valuable as a stock or for hybridization with the mangosteen.

PILI, *Canarium ovatum* Engl. BURSERACEÆ. (Plate VIII, *d*.) A rather large tree, 15 to 25 meters in height, of medium compact growth and rigid branches; leaves about 40 centimeters long, 7 to 13 pinnate, with pinnæ 10 or more centimeters long, rather thick, dark green, prominently veined; flowers in axillary panicles, greenish yellow, rather small and inconspicuous; fruits 1 to 4, ovate to oblong, 45 to 75 centimeters long, more or less triangular in cross section, black, smooth and shining, each containing a nut enclosed in a fleshy husk 325 millimeters thick. The nuts occur in two forms, short and long, and are more or less distinctly three-angled, frequently canaliculate, more or less sharply pointed at each end, brown

and smooth, the short form being from 45 to 60 millimeters long, and the slender form 55 to sometimes exceeding 70 millimeters in length; shell thick and hard; kernel oblong, separating readily from the shell, light, brittle, and of excellent quality raw or roasted.

One kilogram contains 130 nuts, of which the shell constitutes 81.71 per cent and the kernel 18.29 per cent in the short, and the shell 81.13 per cent and the kernel 18.87 per cent in the long kind. According to Dr. H. C. Brill the kernel in each kind gives the following analysis:

Composition of kernel.	Long.	Short.
	Per cent.	*Per cent.*
Moisture	2.79	2.9
Fat	74.37	72.53
Protein (N x 6.25)	12.06	11.88
Sucrose	.88	.66
Reducing sugars	.45	1.35
Starch (by difference)	4.33	5.11
Crude fiber	2.15	2.42
Ash	2.97	3.15

A glance at the above analysis shows the two kinds to be identical for all practical purposes. The fat, protein and sucrose, are somewhat greater in the long than in the short variety. Unfortunately the short kind is the one usually found in the market, the long variety constituting perhaps 5 to 7 per cent of the total bulk marketed.

The pili is found in southern Luzon, the Visayas and Mindanao in districts having abundant rainfall throughout the year.

Practically all the nuts on the market come from Sorsogon, Albay and Ambos Camarines. The nuts are gathered either in the forest or from trees that have grown spontaneously in the abacá or occasionally the coconut plantations. The pili is never planted and cultivated.

The pili is of very slow growth and while no accurate statistics are obtainable it seems probable that the tree does not produce an appreciable crop until it has attained an age of 10 years. At this age the average annual yield per tree is probably not more than 8 to 10 kilograms. The estimates of the average annual yield per tree from fullgrown trees as given by local growers vary from 30 to 1,000 kilograms, one grower stating that he has an exceptionally large and productive tree that has yielded 5,000 kilograms. An average yield of 100 to 150 kilograms of cleaned nuts is probably a conservative estimate; the yield may be considerably larger. It could undoubtedly be greatly increased by planting budded trees.

Before the nuts are marketed the fleshy husk is removed by

heaping the fruits in piles and covering them with leaves, or placing them in vats or barrels filled with water. The fermentation of the husks permits their ready removal from the nuts in the course of 2 or 3 days by washing in cold water.

During the last 2 years the nuts have been husked by boiling the fruits but this method results in the rapid deterioration of the kernel and renders the nut unsalable.

The boiled husks of the pili are also a common article of food in those localities where the tree grows. In texture and appearance this food resembles the sweet-potato but is tasteless and insipid; there are no data relative to its food value.

The one great defect of the pili is the thick, bony shell which resists any attempt at breaking with the ordinary nut cracker; the nut can not therefore be served on the table like other nuts. such as the almond, chestnut, etc. However, when a practicable method of vegetative propagation shall have been devised, so that selection can be begun among the tens of thousands of seedlings that are found in the pili regions, and "paper shell' pili varieties become established, we may expect a tremendous popular demand for this excellent nut and to see large pili plantations come into existence.

The seeds of another species, C. *luzonicum* Gray, are sometimes erroneously credited with furnishing pili nuts for the market. The nuts of this species are, however, quite distinct from the real pili, being much smaller and blunter at the ends. The nuts are of good quality, and the tree has the distinct advantage over the pili of succeeding on very poor and shallow soil where the dry season is long and pronounced, qualities that might make it a valuable stock for the pili and extend the cultivation of this nut far beyond its present area.

Many short-sighted people are inclined to regard fruits as more or less unnecessary luxuries, belittle their culture and consider their production rather unimportant. While rice, corn and certain root crops are willingly conceded to be the *piéces de résistance* of our population, probably most people are also willing to admit that without the addition of more savory dishes these would make a dry and monotonous diet. Fruits serve as appetizers, and supply several elements that stimulate digestion. Let us not forget that many fruits are rich in carbohydrates—fuel, so to speak—and some contain considerable protein.

There is always a ready market for good fruit and it is safe to state that no part of the Philippines is yet oversupplied in this respect. All sections would be decidedly better off economically and otherwise if more and better fruits were grown and

in greater variety. However, while the extension of a fruit into new territory is desirable, good judgment should be exercised in introducing fruits into a locality where they have not hitherto been cultivated or disappointment and financial loss may result. For instance, it would be folly to attempt the cultivation of the mangosteen or the lanzone in those regions which have a long, dry season, or to grow mangos in sections where the rainy season coincides with the flowering period of this tree; nor would it be advisable to plant citrus trees or pineapples on annually inundated or poorly drained land, or where the rain is insufficient, unless these exigencies were provided for. In other words, while the cultivation of a few fruit trees of various species is always to be encouraged, in fruit growing, considered as a business enterprise, the would-be fruit grower should limit himself to those species and varieties that experience has shown to be adapted to his local soil and climatic conditions.

CLINICAL OBSERVATIONS ON COCCIDIOSIS IN CATTLE AND CARABAOS.[1]

By C. H. Schultz, M. D. V., D. V. M.[2]

During the latter part of 1912 and until May, 1913, my duties as assistant in the veterinary research laboratory at Alabang permitted careful observations of numerous cases of experimental rinderpest. The great number of "atypical cases" soon attracted my attention; these had been noted by many observers and were invariably classed and accepted as atypical cases of rinderpest. Rinderpest in the experimental animals was produced by the subcutaneous injection of virulent blood into nonimmunes.

In the middle of August, 1913, I was sent to look after the large number of work animals of the Calamba Sugar Estate at Canlubang, Laguna, where losses from obscure causes among cattle had been severe for some months previous.

Most of the horses and ponies on the estate had perished from surra, but the microscope failed to show the well-known trypanosomes in cattle or carabaos, although several hundred animals were subjected to the usual blood examinations.

Many of the work oxen were dying and a great number were in such a weak physical condition that they were unable to work. The causes of these repeated losses were obscure, and after a reasonably careful survey of the situation it appeared that the deaths and condition of the animals were due to different factors. A great number of the weak animals, however, suffered from irregular evacuations of the bowels; some had diarrhea, more or less severe, and others had what appeared to be "tropical dysentery." The latter were greatly emaciated and cachectic, although continuing to eat as long as they could. Their temperatures were invariably a degree or two above normal. Others, in somewhat better condition, showed as a common symptom an irregular, persistent diarrhea, with only occasional distinctly dysenteric evacuations. Of about fifty animals that were kept together, some were always neat and trim, fat, and able to do

[1] Paper presented before the Manila Medical Society, July 6, 1914.

[2] Formerly of the veterinary division, Bureau of Agriculture.

good work, and were never sick. Those that had been on the place several years appeared to do best. No particular type appeared to be immune, but the young animals were attacked in greater number than the old. Thirty work oxen had died during the month of August. In previous months the losses were, I was told, greater; various causes were ascribed, among others being poison weeds, gastritis due to excess of alkali in plants or water, and other equally obscure ailments.

As soon as possible the sick animals were segregated and divided into different groups, so as to facilitate the study, and, if possible, permit an identification, of the unknown disease.

On August 30 the presence of rinderpest as one of the causes was established. Clinical history, symptoms and post-mortem findings all sustained the diagnosis.

Simultaneous inoculations were begun on a lot of 35 animals on September 4. These were injected with 2 cubic centimeters of virulent blood brought from Alabang, receiving at the same time 100 cubic centimeters of anti-rinderpest serum. Eight of the oxen showed temperatures from 39° to 40° centigrade, when they were inoculated and one, No. 303, registered 41.5°. The animals had been worked hard until the evening before the injections, thus giving no opportunity to examine them clinically, except to take one evening and one morning temperature.

The results of these hasty simultaneous inoculations were, to me, most remarkable. Several of the weak, high-temperature animals died in a few days; some of the others, after four days, began to have a severe diarrhea, becoming dysenteric. Feces, at first dry, hard, and coated, soon showed large flakes of mucus, tinged with blood. This dysentery was of the same type as that observed in cases of experimental rinderpest during my stay at Alabang, where it was considered pathognomonic. As a result of the rinderpest-blood and antirinderpest-serum injections, some of the animals were depressed and suffered as if they had ingested corrosive poisons in dilute state. Others rallied after the first few days, but lost strength and drifted into a cachetic condition lasting weeks.

Diseases that produce acute dysenteric attacks of such a severe and persistent type in domestic animals are few, and, as in human beings, are invariably due to specific causes.

A few days before, while examining blood slides from carabaos for surra, slides of mucus from diarrheal feces were examined microscopically and numerous round or oval, more or less granular, transparent cysts, with a neat double contour, which were at first accepted as ova from intestinal parasites, were noted.

In the dysenteric feces very few of these could be found, but upon closing the diaphragm to the proper point, thousands of elliptical or irregularly oval, granular, transparent bodies, with vague outlines but showing a well-defined nucleus, were at once observed. These were the same as those observed on slides from the intestines of castrated bullock No. 235, which died on August 25. On August 26 similar bodies and rounded cysts were found in the feces of No. 92, an old animal that was greatly emaciated and afflicted with chronic diarrhea and occasional dysenteric attacks. The same organisms were found in a middle-aged animal, No. 74, which died August 27 after a lengthy attack of diarrhea. These oblong, more or less granular bodies were scarce, but other forms, irregularly club shaped, of indefinite outline, often presenting a well-defined nucleus, were present in great numbers.

Since these organisms were constantly found in immense numbers, and always associated with and usually in the mucus flakes, their relation to the dysenteric feces could not be denied.

On August 28 a group of 12 animals was confined in the Canlubang corral; in the feces of seven of these, the same organisms could be found in great numbers. On September 1 castrated bullock No. 37, which had a temperature of 40.4° (one degree less than its temperature of two days before), and was very weak and emaciated, was selected by Doctors Ward and Boynton as a clinical case of rinderpest and destroyed for post-mortem examination. I assisted at the autopsy. The lesions corresponded to those found in acute rinderpest, except that no ulcers were found in the bucal cavity. Blood taken from the cadaver and injected into a nonimmune experimental animal at the research laboratory at Alabang failed to reproduce the disease.

It was not until September 20, after making careful observations in the field and in the immunization corrals, and after due consideration of the notes taken at numerous post-mortem examinations, that I was able to establish the final diagnosis of acute or chronic coccidian gastro-enteritis.

Once the cause was known field observations became simplified. During August and September all work animals suffering from diarrhea or dysentery, as well as those that were cachectic, were sent to the Canlubang corral. Soon after the early reports to Mr. N. C. Campion, then in charge of the Calamba Sugar Estate, the question of clean drinking water for the animals was taken up, and it was due to his energetic efforts that watering troughs for the work cattle were put up in suitable places and kept filled with artesian water. The corrals were supplied with

pumps and troughs, so that even the weak animals could have free access to clean drinking water. This, together with the dividing of the large herds into small units and the feeding of a good allowance of cut forage, decreased the death rate and lessened the number of weak animals.

Forty-four cattle (34 of which were afflicted with the disease in question) which were kept in the Canlubang corral, looked after with reasonable care, fed regularly and supplied with clean creek water in a watering trough, made slow but steady recoveries. Feces from several of these animals, as well as from all those that died, were examined, invariably with the same results. Blood smears were always negative. On October 4 this herd was turned out to graze on nearby pasture. These animals had been checked up carefully and as far as possible, were well known to me. After they had been driven to grass for two weeks, many began to lose weight, looked depressed, and were languid; several became afflicted with excessive watery diarrhea but not dysentery. After losing flesh and strength, about one-third of these animals become anemic, cachectic and greatly emaciated, and died from coccidian enteritis. Some of them rallied and made a good recovery, but many remained chronic invalids.

It is typical of protozoan diseases that the contagion exists outside the body in insects (as in malaria or Texas fever), or in water pools or on swampy ground (as in coccidiosis), and since the virulency of subsequent attacks depends upon the amount of virulent material ingested, these cases were not relapses, but were due to reinfections. This conclusion enabled me to lay the blame on infected swampy pastures or waterholes.

When we attempt to solve a problem with one or more unknown quantities, it is necessary to compare these unknown with known values. Fortunately I was able to compare the disease that was so extensive, obscure and so difficult to distinguish from rinderpest, with other diseases due to coccidia.

In 1902, while in the United States Meat Inspection Service at Tacoma, Washington, a peculiar condition in the liver of lambs attracted my attention; the microscope demonstrated as the cause a sporozoön (coccidium); tissue was forwarded to the Bureau of Animal Industry at Washington, D. C., where my diagnosis was confirmed.

Again in 1906, while in general practice in Tacoma, Washington, a great mortality among Belgian hares was identified as coccidian enteritis, due to *Coccidium oviforme* (not *C. perforans*).

The literature on coccidiosis in cattle has until the last few

years been very scanty. The earliest publications appeared in the "Schweizer Archiv für Tierheilkunde," Volume XXXIV, 1892, from the pen of Doctor Zschokké(1) (Zurich) and Doctor Hess(2) (Berne). In 1893 an article by Doctor Guillebeau(3) (Berne) on *Coccidium oviforme*, causing red dysentery in cattle, was published in Berne. All the textbooks on veterinary medicine and therapeutics as well as on protozoan parasitology refer to these articles.

During the time that I was making observations in this herd in the Canlubang corral, three different lots of cattle were subjected to simultaneous inoculation against rinderpest. The first lot, containing, as stated, 35 animals, was inoculated on September 4; the second lot of 30 was inoculated on September 18; and the third lot of 30 on September 30. The usual method of injecting 5 cubic centimeters of virulent blood, from an animal in the early febrile stage of rinderpest, simultaneously with about 300 cubic centimeters of anti-rinderpest serum, was adopted. All the animals that, as a result of these subcutaneous injections, showed fever, and sooner or later diarrhea or dysentery, had present in their evacuations blood-tinged mucus flakes, characteristic of coccidian dysentery; clinically they presented no difference from the acute type of field cases which were studied at the beginning of the outbreak and which had to be accepted as acute coccidian enteritis.

Material for clinical observations was most abundant, and on account of the great mortality, the clinical history of several cases could usually be supported by post-mortem examinations.

Observations were made on more than 120 field cases and 95 animals that were subjected to simultaneous inoculations. Of these, 35 animals were checked up in a systematic manner. Post-mortem examinations were made and notes were taken in 32 cases of coccidian enteritis.

Many of the animals that were subjected to simultaneous inoculations made slow and unsatisfactory recoveries; they became anemic, cachectic, and suffered from chronic diarrhea, which would at times assume a more or less dysenteric type; several died and many remained so weak that they were useless as work animals.

The observations on all these inoculation cases of rinderpest corresponded in every particular with the acute or chronic type of field cases, where the diagnosis of coccidian gastro-enteritis was arrived at after careful consideration of history, symptoms, post-mortem reports, microscopic examinations and due consideration of available literature.

In the latter part of October, after having spent two months on this estate, orders from the central office assigned me to duty elsewhere, and I have since been able to make only one short observation trip to Calamba (November 5, 1913). The next opportunity that permitted study and verification of the observations taken in the field came in February, 1914, when I was requested to carry out experiments with the cultivation of rinderpest virus in vitro. Part of the immunization sheds at the Pandacan quarantine station were reserved to accommodate the experimental animals, while the cultures were kept in incubators and the laboratory work was done, by permission of Dr. Alvin J. Cox, Director, and Dr. E. L. Walker, Chief of the Biological Division, in the laboratories of that division of the Bureau of Science.

All the animal inoculations or cultures were begun with virulent blood obtained from cases of experimental rinderpest as they have been studied and as they occur at the veterinary research laboratory at Alabang.

Two types of animals were used in these experiments: a larger, coarse breed from Dalupiri, all males, and smaller, neater, nervous animals, all females, from the Island of Fuga. From observations made at Alabang, it was known that the Dalupiri animals were more susceptible to one type of disease, and the smaller Fuga cattle to another. This phase of the experiments, if definite observations could be made, would divide the sick animals into two classes.

The first two animals were inoculated on February 9 with 5 cubic centimeters and 2 cubic centimeters, respectively, of citrated rinderpest blood obtained from Alabang. Both animals, Fuga female No. 3717 and the Dalupiri male No. 3696, died on the 10th and 12th day, respectively, after the inoculation; the diagnosis was confirmed by lesions found at autopsy.

Blood from these two animals was obtained and mixed on February 17, when the disease was clinically identified as rinderpest, and Fuga female No. 3706 and Dalupiri male No. 3690 were each injected with 10 cubic centimeters of this citrated virulent blood. The Fuga cow succumbed to a clinically not well-marked attack of rinderpest with only moderate temperature reactions. Autopsy, however, showed marked lesions of rinderpest.

In the Dalupiri male (3690), a strong vigorous animal, the disease developed into a well-marked, typical case of acute rinderpest; the highest temperature (41° C.) was observed on the fifth day; the period of high temperatures was from the

fourth to the eighth day; the attack was of long duration and the animal made a slow recovery, without relapse. Diarrhea began on the 7th day, and on the 8th day the evacuations became offensive, a great deal of mucus being passed. This severe diarrhea, often dysenteric, persisted more or less for 20 days, when feces began to assume normal form and the animal began to show rapid improvement. On the 15th day a dry, scaly skin eruption, extending over neck, shoulders and back, made its appearance. The type of diarrhea of this animal, and the symptoms as they were produced during the course of this disease, were identical with those of an acute, severe attack of coccidiosis, although it was caused by the injection of 10 cubic centimeters of citrated virulent blood from clinically identified rinderpest cases, showing at subsequent autopsy well-marked typical lesions.

The animal was turned out to pasture on March 17. Since then it has done well, but passes coccidia in feces. On March 28 it was reinjected with 10 cubic centimeters of rinderpest blood; it was immune, no reaction being produced.

With No. 3690, which was a clinically typical case of rinderpest with great loss of flesh, marked offensive diarrhea and dysentery, and which made a slow but steady recovery, we must compare some of the atypical cases, especially those that result in death in a few days and show constipation instead of diarrhea.

Animals that become afflicted in a pronounced manner, where the clinical symptoms are marked and readily permit a correct diagnosis, present no difficulty. Only few of the reactors showed definite symptoms. In many the reaction was unusually obscure.

The post-mortem notes taken during my stay at Calamba had shown that the cause of death, in a certain number of cases, was a septicemia, causing hemolysis, with dark tarry blood which was unable to carry oxygen, and, therefore, death invariably resulted in a few days, without great loss of weight or marked emaciation—an acute, even peracute, attack. On the other hand, animals that lived through this first more or less septicemic period would invariably become afflicted with a more or less severe diarrhea or dysentery. These lived longer, became gradually weaker, and lost flesh; the pathognomonic symptoms were dysentery, weakness and slow cachexia, but not acute toxemia as in the first type. Other cases were of the mixed type, the attack being less acute, the symptoms of the hemolytic (septicemic) increasing more slowly and changing gradually into the diarrheal-dysenteric, finally terminating in death or recovery, as the case might be.

Fortunately the post-mortem findings of the two types of disease present beautifully distinguishable features.

Post-mortem notes.—The disease of the first or hemolytic type produces lesions characteristic of a hemorrhagic septicemia. Discharge from eyes and nose is often present. The blood escaping from cut vessels appears dark, tarry, does not coagulate well, and more or less pronounced hemolysis stains the serum. The blood-vessel walls permit escape of tinged serum and cellular elements into the adjacent tissues, thus causing the characteristic hemorrhagic extravasations found throughout the cadaver. In aggravated cases entire regions are found discolored in this manner. Blood extravasations into the subcutaneous and muscular tissues are frequently obscured. The Schneiderian membranes are dark red or bluish red, covered with hemorrhages. The mucosa of the larynx and pharynx shows hemorrhagic and croupous inflamation, and its epithelium is often eroded. Throughout the thoracic cavity, subpleural hemorrhagic extravasations attract attention at once; often the inter-costal spaces, especially on each side of the vertebral column, are stained dark blood color. Hemorrhagic or petechiated areas are found on the pericardial sac, on the myocardium and in the ventricles. The valves of the heart are often deeply stained. The lungs show, throughout their tissue, more or less marked areas of hemorrhagic inflamation and corresponding discoloration. The lymph glands are similarly infiltrated. In the abdominal cavity the serous layers are covered with blood extravasations. The blood-vessels are ribbonlike and are dark colored because the fluid escapes through the permeable vessel wall. The mucosa of the fourth stomach is intensely congested, shows numerous hemorrhagic areas and incipient ulcerations in the acute stage. Throughout the intestinal tract similar lesions are found—all evidently recent and acute, with extensive hemorrhagic extravasations under the mucosa or into the lumen of the bowel. The liver is usually engorged with blood and may appear mottled, showing regions of parenchymatous degeneration or biliary stasis.

The disease of the second or diarrheal type, on the other hand, will invariably present lesions typical of a severe gastro-intestinal disturbance, due to rapid, more or less extensive destruction of the mucosa by agamic multiplication of coccidia in the different parts of the intestines. If the animal has been sick 8 days or more, the cadaver shows marked emaciation. The eyes are clear but sunken. The abomasum, the duodenum, cecum and rectum are usually severely involved, while the lesions in the jejunum, ilium and colon appear less marked. The defects of the mucosa permit escape of blood through the destroyed epithelial layer. Destroyed cells, blood elements and serum, mixed with intestinal secretions and ingesta, form the thick slimy layer covering the mucosa of the affected parts. This layer has a more or less offensive odor and is a favorable medium for the multiplication of secondary (bacterial) invaders. Parts of the bowels involved in this manner can often be recognized as soon as the abdominal cavity is opened, as they have a peculiar

bluish-gray or slaty color, and appear quite anemic. Pleura, heart, diaphragm, liver and mesentery are pale, anemic, but bright and glistening, free from the characteristic hemorrhagic extravasations always found, and pathognomonic to the hemorrhagic-septicemic type. The vessel walls do not permit the blood to escape into the surrounding tissues and are, therefore, well defined and distended on a pale, anemic background. The blood is bright red and forms firm buff-colored clots.

Since to the first type are due the peracute and acute attacks, and to the second type the somewhat slower acute and chronic cases, it is evident that the diarrheal form supersedes the hemorrhagic-septicemic period. When animals die during certain stages of the pest, the lesions found on autopsy will be of a mixed type, approaching more the septicemic or diarrheal type, corresponding to the type of disease which predominates at the time of death.

If we remember and consider the clinical history and the causes producing the different clinical symptoms, they will in a large number of cases correspond to the autopsy reports, which permit us to recognize as cause of death (1) a hemolytic or hemorrhagic-septicemic, (2) a diarrheal, and (3) a mixed type of disease.

The course of the disease in all animals suffering from the diarrheal form can readily be followed by the type of diarrhea or dysentery. The microscope permits ready identification of the kind and approximate number of coccidia. These examinations can be made in a systematic manner, similar to examination of stools from human sources for bacilli or amebæ. Coccidia produce dangerous dysentery only during their asexual multiplication, where young immature asexual forms and merozoites are passed out in incredible numbers. When forms produced by sexual conjugation—macro-gametocytes, micro-gametocytes, oöcytes or the smaller cystic forms—begin to appear in the mucus, schizogony has reached its limit, and the host, if not too weak, will improve in a marked degree in two or three days, and recover.

Such cases could be recognized, studied, diagnosed and a reasonably correct prognosis made.

If some way could be devised to identify and to diagnose the septicemic cases, enabling us to form a proper diagnosis early, the study of the disease proper could then begin.

In an effort to determine what could be done, it appeared that some sero-diagnostic method would be indicated.

Dr. A. Marmorek,(4) of the Pasteur Institute in Paris, in 1909 diagnosed tuberculosis in humans by using rabbit and sheep

corpuscle-hemolytic-amboceptor, urine from tuberculosis patients as antigen, anti-tubercular serum as anti-bodies and guinea-pig serum as complement.

This method appeared to be well worth a trial. On March 14, suitable clinical cases being on hand, the method received its first trial. Dr. E. H. Ruediger, of the Bureau of Science, kindly furnished the hemloytic amboceptor. In titrating for the complement-deviation values, it was at once noted that the antigen—the urines from animals sick with this type of disease—dissolved the blood corpuscles with marked rapidity, so that it could not be used for this purpose. Since the urine of animals suffering from hemolysis had this property and it was found possible to heat such urines with only slight diminution thereof, the problem assumed a new and more favorable aspect.

After many trials it was found that 0.5 cubic centimeter of a 10 per cent normal salt solution and sheep-corpuscle emulsion, and approximately 5 cubic centimeters of fresh but filtered urine gave the best results. Urines can be heated to 60° or 70° C. for 30 minutes and lose but little of this property. They will then keep for weeks, although in my cases (about 250 samples) a marked diminution of the clearness of the reaction was noted after 20 days.

A series of suitable test tubes is taken. Into each is placed 0.5 cubic centimeter of 10 per cent sheep-corpuscle emulsion; 5 cubic centimeters of the urine to be tested is added and the tubes are set away at room temperature (20° C.) for 24 to 36 hours. A tube with 0.5 cubic centimeter sheep-corpuscle emulsion and 5 cubic centimeters of salt solution is used as one check, and another tube with 0.5 cubic centimeters sheep-corpuscle emulsion and non-reacting urine is used as another. The tubes must be kept in a perpendicular position.

In urine from animals that are not afflicted with the hemolytic type of the disease the blood corpuscles will settle in a button on the bottom of the tube, similar to the checks, which do it regularly. The urine above may be clear, hazy or even turbid. On the other hand, in acute cases of the hemolytic type, a very rapid and complete dissolution of the corpuscles takes place and the entire tube becomes bright red and translucent. When 5 cubic centimeters of urine dissolve 0.5 cubic centimeter of 10 per cent blood-corpuscle emulsion, this hemolytic factor can be expressed as $\frac{5}{5}=\frac{1}{10}$, showing a dangerous attack. Urines can be titrated as to the amount of sheep-corpuscle emulsion that they can dissolve. A factor of $\frac{2}{10}$, in the cases that I

have examined, invariably signified death in a few hours or the next day. Between these extremes, all kinds of degrees of hemolysis may be observed. The button may form and a dark-red zone, extending 1 centimeter above it, will indicate a moderate, not dangerous, attack. In other cases, the corpuscles settle into an indistinct dark-red, shallow area in the cupola of the tube, with a marked hemolytic zone, coloring two-thirds of the urine red. If samples of urine are taken every day, the course of the disease can readily be followed. These hemolytic periods are subject to marked variations. In artificially produced rinderpest (blood injections), the reaction is severe on the 4th or 5th day (occasionally sooner), maintains itself during 3 to 10 days, and becomes gradually less until at last the corpuscles settle rapidly into a firm button and the animal can be considered very resistent against an injection of approximately the same virulence. As long as the condition becomes worse the hemolysis in the tube increases; when the hemolysis decreases and a button of definite form appears, the animal is improving. As simple as this is, it constitutes an exceedingly valuable diagnostic aid. The urines are gathered in wide-mouthed bottles and filtered directly into the test tubes. These are labeled, heated to 60° or 70° C. for 30 minutes, cooled and tested as soon as desired, or stored away.

One tube alone will, of course, prove whether the process in question is developing in the animal or not; a series of tubes, however, will show to a nicety the course of the disease. Observations taken on probably 30 animals, in all stages of the disease, show that when executed carefully and cleanly this method is reliable and very practicable. I do not claim that it is a "specific" reaction, but it is a diagnostic method permitting the observation of otherwise invisible phenomena.

It will no doubt be asked why rinderpest should be here diagnosed when this paper discusses coccidiosis.

The two diseases are so intimately associated and so difficult to differentiate clinically that I hailed with great delight this diagnostic method, and thought that, being able to eliminate coccidiosis with the microscope and diagnose rinderpest by urine test, the study of either disease could really begin.

Dalupiri bull No. 3694, which had been carefully kept among the non-immune experimental animals, was noted to have a slight but persistent diarrhea beginning in an obscure manner about March 15. On April 22, the diarrhea persisting, the animal was isolated, and the evening temperature was found to be 39.6°; it remained above 39° in the evening and above 38° in the

morning for weeks. A dry scaly skin eruption appeared on the fore quarter and neck; at times there was a slight nasal discharge, and soon after the diarrhea became well established coccidia could be found in the feces. The animal lost a little weight, but was always bright, quarrelsome, relished its rations, and at times ate ravenously. Coccidia in great numbers were found in the feces, including many young asexual and a few cystic forms. This type of animal is especially susceptible to coccidian gastro-enteritis. It had been noted before, however, when animals of this type were used for rinderpest experiments at the veterinary research laboratory, that they had high temperatures, so that the Fuga cattle were preferred, and the Dalupiri animals were discarded. No attempts were made to identify the cause of the thermic rise. For this reason No. 3694 was a useful and acceptable addition to the animals under observation, to study the co-relation of the hemolytic and diarrheal types of the disease. This had heretofore been a difficult problem. Urine tests were made as follows:

Previous to April 15—negative.

Hemolysis extended on April—					
15.	18.	20.	24.	28.	30.
none	[a] 0.25	[a] 0.50	[a] 0.25	[a] 0.25	[a] 0.25
Hemolysis extended on May—					
2.	4.	6.	8.	11.	13.
[a] 0.25	none	none	[a] 0.25	[a] 0.25	none

[a] Length of tube.

This slight but persistent reaction was coincident with the finding of coccidia in the feces extending over many weeks. The animal was fed on good hay which temporarily lessened the diarrhea. The high temperature, the remarkable appetite, the dry, slightly scaly skin eruption, the presence every few days of more or less mucus with the different forms of coccidia and the slight but recurring attacks of hemolysis as demonstrated in the urine were all due to a naturally acquired coccidian infection. It is the first one that has come under our observation in the earliest stages.

This case of coccidiosis showed all the symptoms, in mild form, that a pronounced case of rinderpest presented—nothing was wanting.

On April 18 a medium-sized carabao, brought in from the country, came under observation. It appeared perfectly normal; the temperature was not markedly increased, but the feces were not constant in character, at times soft, at times coated with mucus, occasionally appreciable masses (not flakes) of mucus were expelled, and these showed schizogenous forms of coccidia in enormous numbers in every microscopic field. In the thin flakes of mucus, the sexual, cystic forms were numerous. The urine showed:

Hemolysis on May—			
18.	20.	22.	25.
none	none	very slight	[a] 0.25

[a] Length of the tube.

The animal was then taken away and could not be observed further.

It was decided to subject No. 3694 to a test inoculation of rinderpest blood, because it appeared that, if the diseases were identical, immunity would certainly have been produced between April 22, date of isolation, and June 11, date of injection of 5 cubic centimeters of virulent blood. The high virulence of this amount was demonstrated by the severe attack experienced by other animals in the same series.

The temperatures of the animal at the time of injection were 39.4° in the evening and 38.3° in the morning, which were too high, indicating a chronic, more or less serious disturbance. On the 4th day after the injection of virulent blood the temperature rose to 39.5° and 40.6°, respectively, and on the fifth day to 40° and 40.5°. Diarrhea became aggravated, dysentery began on the 9th day and rapidly increased in severity; still No. 3694 showed a remarkable resistence and was eating a little grass one day before it died—emaciated to a skeleton.

Post-mortem lesions were absolutely identical with those of rinderpest. Scrapings from the ulcerated abomasum, the duodenum, the cecum, the colon and rectum, however, showed young forms of schizogenous type of coccidia in countless numbers. All attempts to diagnose rinderpest correctly and to differentiate it from all other diseases will require further study and evidently a series of most carefully executed experiments and observations.

In the attempts to solve this important problem, another disease has been identified and means discovered to establish a

correct diagnosis, so that a careful study of coccidian gastro-enteritis, as found in these Islands, can now begin.

Coccidiosis, or to be more definite, coccidian gastro-enteritis, was observed as early as 1880 on high pastures in some parts of Switzerland. In 1892 Dr. Zschokké(1) (Veterinary School, Zurich) and Dr. Hess(2) (Veterinary School, Berne) published comprehensive articles in a Swiss veterinary periodical on the "red dysentery of cattle," caused by the schizogenous multiplication of coccidia in the epithelial cells of the intestinal canal. Hess states that during the year 1890, 200 cases occurred in the district of Saanen, of which 16 died; during the year 1891, 180 cases were noted, with a loss of 20. Most of the cattle made good recoveries in eight days, some in two to three weeks, while other cases lasted from two to three months. The animals became greatly emaciated and cachectic. Coccidia could readily be demonstrated in enormous numbers, especially in the abomasum, cecum, colon and rectum. Infected drinking water from swampy pastures was established as the cause. Hess quotes four instances where the infection was traced to hay, the cattle being kept in stables on dry rations. In a Swiss veterinary publication of 1908 appears a very interesting article on "red dysentery," or coccidian dysentery of cattle, from the pen of Dr. E. Züblein.(5)

His observations supplement those of the earlier writers and he arrives at the same conclusions as to cause and mode of infection. A short comprehensive article in English is found in Vol. II of Dr. Law's(6) "Veterinary Medicine" which is based upon the early observations of the Swiss veterinarians. Since then Dégoix(7), Kitt(8), and others have investigated and published articles on this subject. From time to time interesting articles by different veterinarians have appeared in the technical journals.(9,10) Eustace Montgomery's(11) short, terse article (in English) is published in the Bulletin de la Societé Pathologique Éxotique, 1910, Vol. III, page 293; A. Balfour's(12) article on the same subject is found in the same volume, page 429. The organism causing the disease under discussion belongs to the phylum Protozoa, subphylum Plasmodroma, class of sporozoa (Leukart), subclass Telosporidia (Schaudinn). F. Döflein(13) in his standard work "Protozoenkunde," 3rd Ed., 1909, places them as 1st order Coccidiomorpha (Döflein), suborder Coccidia (Leukart). They are therefore related in some of their characteristics to the Hemosphoridia (Shc.) and Gregarinidæ. No doubt those interested in this subject will find F. Döflein's work the best source of information. Their com-

plex life cycle is well described and illustrated, but the nomenclature of different authors—as is usual—does not agree.

It would appear that the coccidia which were observed are not identical with *Coccidium oviforme* (*Eimeria stiedæ*). On three different occasions oöcytes with eight, free, circumposed, round spores were observed. Whether this will be found to be constant, or whether it was an artifact, only a careful observation will demonstrate. Since coccidia are classified by the number of sporozites formed and their methods of division, this point must be considered as very important in a final classification of these organisms.

Knowing to what class the coccidia belong, a close scrutiny of the parasite can be made, because *sporozoa* as a class come under the same general biologic laws. They all form oöcytes (sporozoites) and these are the forms that permit the termination of the life cycle outside the body of the host, and, through the formation of spores, transmit the disease by means of water and forage. Since sporozoites result only from sexual conjugation, the chronic carriers, in which schizogony is limited and therefore not dangerous to the host, are the distributors of the forms that infect the swampy pastures and, multiplying subject to the stimulus of more or less favorable environment, reinfect new animals and destroy some sensitive new host by the often incredibly rapid asexual schizogenous division.

On page 710 of F. Döflein's(13) work, third edition, the statement is made that many parasites, resembling sporozoids, found free in the blood stream, have been described as drepanidia while they probably were coccidia in certain stages of development, circulating in the vascular system.

If we take blood from an animal recovering from a severe attack of coccidian dysentery, we can, by careful centrifuging and by blood-corpuscle leaching methods, obtain these spores in appreciable quantities. They can also be recovered from feces by sedimentation methods. In urine they are found far more easily, but only the smaller forms, appearing as dense, small, cocci-like bodies under the oil immersion, can be obtained. The larger forms are held back, apparently by the kidney filter.

When spores are first liberated they are quite large, about one-half the size of an erythrocyte. They take eosin or carbol-fuchsin stain, especially when first subjected to a mordant of chromic acid. They lose the color readily, however, 50 per cent alcohol or 2 per cent sulphuric acid decolorizing all the large forms in a few minutes. As the spores become more developed, they show denser capsule and become smaller. We must also

consider that coccidia are readily influenced to modify their method of division; Guillebeau(3) and Züblein(5) report that at 20° to 30° C. the usual division and sporulation take place in *Coccidium oviforme*, but at 39° the division into very small, sphere-like bodies is most rapid and reaches a point where the resulting spheroidal bodies cannot be seen by high power.

After careful study and consideration of the large amount of available material, their presence could be demonstrated in a satisfactory manner by the method mentioned above. Even oöcytes, showing freelying spores surrounded by the intact double-encountered membrane, were observed in washed blood sediment.

In regard to occurrence, Döflein(13) says that coccidia are distributed over the entire world. In these Islands they can probably be found in all animals, wherever mucus flakes can be detected by a careful microscopic examination of the dejecta. During the last dry season, the animals on a certain tract of land along the Pasig River showed normal feces. About two or three weeks after our early heavy showers all the immune cattle, Chinese and Indian, as well as sheep, goats, horses and later even hogs, showed marked constipation, the feces being passed in hard-formed masses, often hanging together on mucous strings, and in these flakes the sexual-division forms of coccidia were found in enormous numbers.

A herd of 21 carabaos, fine large animals, imported a few years ago from Pnom Penh, apparently in the best of health, were all constipated and the feces appeared coated or varnished. Examinations under the microscope always established the same diagnosis. Cattle from Mindoro were also markedly affected. Cattle from the Batanes Islands, especially a shipment of carabaos and cattle from Dalupiri, were greatly constipated and their feces, formed into small, hard, dense pellets, or rouleaux formation, were covered with blood-tinged mucus, which could be recognized with the naked eye. One of this lot, however, an old cow, had a marked attack of diarrhea, during which masses of mucus with the well-known schizogenous forms appeared.

This early constipated stage is pathognomonic of coccidiosis and is superseded by the dangerous dysentery only if the host is susceptible and his body cells cannot inhibit the rapid and destructive agamic multiplication.

A notable exception is to be recorded in chickens, which show the symptoms early in the coccidial season, usually by a muco-

sanguinous diarrhea with large intestinal mucous casts, in which the club-shaped merozoites alone appeared, often in rosette formation, not yet separated. The birds stopped laying, were dumpish and their combs were bluish or gray instead of red; they appeared as if they were going through a heavy molt, without losing their feathers.

It appears therefore that coccidiosis in its chronic form, although it has escaped notice so far, has an extensive distribution throughout these Islands. In this form it is practically harmless, although many ill-nourished young animals may be retarded in healthy development by an invasion, and the subphylum of sporozoa will no doubt soon be charged up with much of this loss on the part of our agricultural communities.

While chronic coccidia carriers are not seriously affected, having acquired immunity themselves, they infect the feeding grounds and watering places of susceptible animals, and more information on this phase of the coccidial life cycle must be obtained. We do not know the exciting cause, the stimulating factor, that produces epidemic outbreaks among cattle. From the numerous observations made in our rinderpest experiments, it would appear—remembering the peculiar methods by which coccidia can divide into most minute organisms (Züblein,(5) 1908)—that one part of their life cycle could be passed in the blood-vascular system and that their rapid multiplication in most minute forms produces the hemolytic form of the disease. This is superseded, if the host lives, by the diarrheal form, the latter being necessary to reinfect other hosts and transfer the contagion from one place to another.

Guillebeau(3) (1893) states that some animals succumb on the second day. This is impossible even if the epithelial cells are damaged by excessively rapid schizogony. A rapid multiplication in the blood stream of an organism which is ultra microscopic during a part of its life cycle, however, offers the best and most plausible explanation. Dr. Y. F. Löffler(14) (1911), in his dissertation on filtrable viruses, says that the different results obtained by various investigators relating to the filtrability of the virus of a certain disease may often be due to the fact that the virus from the same strain may be composed of larger or smaller particles, according to the stage of development at which it happened to be in the material that was filtered.

E. Montgomery,(11) in his article previously mentioned, in speaking of an epidemic outbreak of coccidiosis in East Africa,

states that clinically coccidian gastro-enteritis cannot be differentiated from rinderpest, but that rinderpest can be transmitted by blood inoculation, which is not the case with coccidiosis.

Our observations show that the history, development, clinical symtoms and post-mortem findings of acute coccidian gastro-enteritis and acute rinderpest cannot be distinguished, that they are identical, as Montgomery says. In one disease however, coccidia in enormous numbers can always be demonstrated in intestinal scrapings and slime from the abomasum, duodenum, cecum, colon or rectum, obtainable in large quantities on post-mortem examination.

We cannot deny that acute coccidiosis has invariably been associated with rinderpest inoculation. Our last cases, Nos. 3694 and 3714, died from coccidian gastro-enteritis of the most severe type after receiving a subcutaneous injection of 5 cubic centimeters of rinderpest blood.

Since we have been able to recognize coccidiosis, it has never been possible to find a case of rinderpest without the presence of these organisms in great numbers.

Animals immune to rinderpest have, in the large majority of cases, been observed to be periodic carriers, or secretors, of coccidia in different forms. As examples, may be cited bullock No. 3554 and the Nellore Indian Cattle from the Iwahig Penal Colony on the Island of Palawan.

Of four guinea pigs that were inoculated on April 21 with blood from spore-carrying cattle, two died about June 12 from coccidian dysentery, one died from pneumonia, and one is still alive and doing well. Dr. E. L. Walker's guinea pigs, kept in the same room and fed the same way, have never shown any disturbance; Dr. Ruediger, a careful observer, has assured me that none of their small experimental animals have died from similar trouble.

Many authorities have also arrived at the conclusion that rinderpest cannot be a bacterial disease, that it belongs to the scourges due to protozoan invasion. The peculiar bahavior of animals susceptible to rinderpest indicates that they have only a lesser or greater resistancy. The numerous "relapses" observed in the Calamba outbreak were nothing else than reinfections due to infected pastures. This does not correspond with bacterial immunity but finds a ready explanation when the general laws underlying the acquirements of immunity—or to be exact, resistance—against protozoan diseases are considered.

A good illustration of nature's method of producing immunity

against protozoa is found in our southern States where cattle inoculated by ticks with piroplasmosis for generations have acquired a very high resistance.

In the Tropics, malaria is the cause of many deaths among children, while the adult population is very resistant, although being very often carriers and susceptible to very large doses of infected blood.(15)

Staff veterinarian F. Mrowka(16) (1914), writing from Tsingtau, where he had ample opportunity to observe the East Asian rinderpest, says:

> No doubt can exist, that the virus is found in the body in latent forms, that the cause for relapses is to be looked for in the mucosa of the abomasum and that its virulency is reëstablished by excessive exertions or changed conditions of life which affect the immune animals unfavorably.
>
> This explains why animals, able to resist artificial and natural infection, and therefore apparently immune, occasionally become sick with rinderpest, so that the words "immune to rinderpest" really mean afflicted with rinderpest in latent form.
>
> We must distinguish virus carriers and virus secretors. All animals immune to rinderpest, though absolutely harmless to their surroundings, may have a relapse and thus become virus secretors. This peculiarity identifies rinderpest as one of the many protozoan diseases.

It is evident, then, that it will be very difficult to separate rinderpest from coccidian gastro-enteritis.

I wish to express here my thanks to Director Alvin J. Cox for the freedom of the Bureau of Science laboratories, to Dr. E. L. Walker, for many attentions and ever-ready words of encouragement, and to Dr. E. H. Ruediger, Dr. J. A. Johnston and Dr. Otto Schöbl for their kind assistance.

This work and these observations were possible only through the interest and suport given by our chief veterinarian, Dr. Stanton Youngberg, and I desire to express my appreciation of his aid.

I hope that these notes will promote an advance along rational lines against a dangerous, disturbing factor in animal husbandry and that they will be of assistance in acquiring more knowledge and a better understanding of this class of disease.

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CURRENT NOTES—SECOND QUARTER.

NOTES BY P. J. WESTER, Horticulturist in Charge of Lamao Experiment Station.

SHIELD BUDDING TROPICAL FRUITS.

As noted elsewhere in this issue of the REVIEW experimentation in vegetative propagation of tropical exogenous fruits is a feature of the work at the Lamao Experiment Station, and the following species were in 1915 successfully shield budded for the first time: bignay, *Antidesma bunius;* calumpit, *Terminalia edulis;* iba, *Cicca disticha;* mabolo, *Diospyros discolor; Flacourtia cataphracta;* bael, *Aegle marmelos;* vilatti, *Feronia elephantum;* banauac, *Uvaria rufa.* Detailed information relative to the budding of each of the above species, as a result of the experiments, is given below, as well as to the budding of the tamarind, *Tamarindus indica;* cashew, *Anacardium occidentale;* barobo, *Diplodiscus paniculatus;* seagrape, *Coccoloba uvifera;* camia, *Averrhoa bilimbi;* santol, *Sandoricum koetjape;* and hondapara, *Dillenia indica.* The tamarind was first shield budded by the writer in 1905, in Miami, Florida and the work verified here; the cashew in 1912 at Lamao; the remaining species were first budded successfully in 1914.

By "petioled budwood" is understood a twig cut at the time of budding and the petioles cut off close to the bud at the time of the insertion of the bud, as for instance in the citrus fruits, avocado, guava, etc. By "nonpetioled budwood" is meant a twig, the leaves of which were cut off while still on the plant some time previous to the date of budding, say three weeks, and from which in consequence the petioles dropped and a scar formed. Nonpetioled budwood should not be cut from a plant, or buds from it inserted, until the scar is well healed. (See this REVIEW, Vol. VIII (1915), No. 1, p. 59.)

Bignay, *Antidesma bunius.* Use petioled, green, smooth, but fairly matured budwood with brown-colored lenticels; cut the buds 3.5 to 4 centimeters long; age of stock at point of insertion of bud unimportant.

Calumpit, *Terminalia edulis.* Use petioled, barely mature, green

and tomentose to smooth budwood; cut the buds 4 to 5 centimeters long; age of stock at point of insertion of bud unimportant.

Iba, *Cicca disticha.* Use nonpetioled, fairly matured budwood, green to turning brown, smooth; cut buds rather large with ample woodshield, not less than 4 centimeters long; age of stock at point of insertion of bud unimportant.

Mabolo, *Diospyros discolor.* Use petioled, fairly mature budwood, but with pubescence still present; cut buds 4 centimeters long and insert preferably at a point where the stock is still green or at most streaked with gray.

Flacourtia cataphracta. Use petioled, matured, grayish to brownish green budwood; cut buds 3.5 centimeters long; age of stock at point of insertion of scion unimportant.

Bael, *Aegle marmelos.* Use petioled, thornless green or purplish, fairly mature, not old and hard budwood; cut buds 3.5 to 4 centimeters long; age of stock at point of insertion of bud unimportant.

In all probability the bael could be successfully budded upon the taboc, *Aegle glutinosa,* which is very drought resistant and is indigenous to the Philippines.

Vilatti, *Feronia elephantum.* Use petioled, turning greenish or grayish, just mature, preferably spineless budwood; cut buds 3 to 3.5 centimeters long; age of stock at point of insertion of bud unimportant.

Banauac, *Uvaria rufa.* Use well matured, dark brown, nonpetioled budwood from which the tomentum has disappeared; cut buds 3.5 to 4.5 centimeters long; age of stock at point of insertion of bud unimportant.

Tamarind, *Tamarindus indica.* Use petioled, well matured, brownish budwood; cut buds 3 centimeters long; age of stock at point of insertion of bud unimportant.

Cashew, *Anacardium occidentale.* Use nonpetioled, mature, grayish budwood; cut buds 4.5 centimeters long and insert in stock at a point of approximately the same age and appearance as the scion.

Barobo, *Diplodiscus paniculatus.* Use petioled, mature, brownish to grayish budwood; cut buds from 3 to 4 centimeters long; age of stock at point of insertion of bud unimportant.

Seagrape, *Coccoloba uvifera.* Use preferably nonpetioled, mature, but green and smooth to turning grayish budwood from slender twigs; cut buds 3.5 to 4 centimeters long; age of stock at point of insertion of bud unimportant.

Camia, *Averrhoa bilimbi.* Use nonpetioled, matured, brownish

or grayish, still downy budwood; cut buds 3.5 to 4.5 centimeters long; age of stock at point of insertion of bud unimportant.

Santol, *Sandoricum koetjape*. Use nonpetioled, fairly mature, slender budwood turning brownish, grayish and rough; cut buds 3.5 to 4 centimeters long and insert in stock at a point of approximately the same age and appearance as the scion.

Hondapara, *Dillenia indica*. Use nonpetioled, slender, fairly mature, green to brown, hairy budwood; cut buds from 3.5 to 4.5 centimeters long; age of stock at point of insertion of bud unimportant.

THE DISTRIBUTION OF THE RAINFALL IN THE PHILIPPINES.

As an aid to the prospective planter unfamiliar with the climate and the foreign seed and plant introduction work in the Philippines, the recently issued "Annual Amount and Distribution of Rainfall in the Philippines" by the Rev. Miguel Saderra Masó, S. J., Assistant Director of the Weather Bureau, prepared under the direction of the Rev. José Algué, S. J., Director of the same Bureau, is one of the most valuable publications published by the Government in the Philippines.

We learn from this publication that, generally speaking, the western part of the Archipelago is characterized by a dry winter and spring, and a wet summer and autumn, while in the eastern part there prevails the winter and autumn rain type.

The Philippines have a mean annual precipitation of 2,400 millimeters, with a minimum rainfall of 900 millimeters in Zamboanga, and a maximum of 4,500 millimeters in Baguio. It is true, however, that these figures do not represent the rainfall for a region of any considerable area, for the values for the driest and rainiest regions of the Philippines of any considerable size are represented by 1,300 and 3,900 millimeters, respectively. Excepting the Island of Cebu, the northern and western coasts of Mindanao and the Jolo group, where the average rainfall is below 2,000 millimeters, all the northern, eastern and western coasts receive an annual mean rainfall of above 2,000. In the low altitudes in the interior of the larger islands the precipitation seldom reaches 2,000, while in the highlands above 200 meters it ranges between 2,000 and 3,000 with a maximum of 4,000 millimeters in the Benguet plateau in northern Luzon at an altitude of 1,400 meters. In certain sections of the eastern and southeastern coasts of Luzon, eastern Samar and northeastern Mindanao, the rainfall averages above 3,000 millimeters. There are no large regions especially dry in the interior of the large islands, or long periods of extraordinary drought.

Broadly speaking, the heaviest precipitation occurs during the summer and fall, from June to November:

During the winter months, December and January, the rains cease on the western part but they continue to fall abundantly on the eastern and northern coasts, thus constituting for the regions facing to the Pacific Ocean and to the larger inland seas quite a second rainy season. February, March, and April are generally the driest months over the whole Archipelago, although as soon as the sun reaches the Northern Hemisphere and the thermal focus is advancing northward, local thunderstorms become more frequent and during May cause heavy showers, especially in the interior of the large islands.

In concluding the leading article, the climate of the Philippines in respect to the rainfall is summarized into three divisions:

(1) Regions with the cyclonic rainfall only, where a dry season practically lasts for six months—December, January, February, March, April, and May. The western coasts of Luzon from Cape Santiago to Cape Bojeador, including the shores of the Manila Bay and the southern coast of Luzon corresponding to Batangas; the central plains and moderately high lands of Luzon from Batangas to Nueva Ecija and Pangasinan; the region of Benguet and the Mountain Province; the western coasts of Mindoro and western Panay and southwestern Negros and the Calamianes groups.

(2) Regions which receive cyclonic and winter rainfall with a relatively dry season lasting only three months or less—generally March, April, and May. The northern and eastern coasts of Luzon, with the Cagayan Valley and Nueva Vizcaya; the Batanes and Babuyanes Islands; the most of southeastern Luzon; eastern Mindoro, Romblon Island, northern Panay, and Negros, northern Cebu, western Bohol and northern Mindanao.

(3) Regions with more or less even distribution of rainfall during the year with the minimum during the months of March and April or in August. The southeast end of Luzon; the eastern Visayas, Masbate, Samar, and Leyte; the northern and eastern part of Bohol, Cebu, Negros, and Panay, eastern and southern Mindanao, Basilan and Jolo.

The publication in question consists of 42 pages, with 76 rainfall tables, and is accompanied by a comprehensive rainfall map with 52 graphic charts by which one can see at a glance the annual mean rainfall of most sections in the Philippines.

We heartily recommend the above-mentioned publication to all who are interested in the climatology of the Philippines.

NOTES ON THE OUTLOOK FOR THE CITRUS FRUITS IN THE PHILIPPINES.

Most people are under the impression that a limited district around a few towns in Batangas is the only section in the Philippines where oranges will succeed, pointing to the inferior fruits that are grown everywhere else, and no doubt the outlook is dismal enough to the casual and superficial observer. Never-

theless, after more than four years' close observation of the conditions here and of the Philippine grown citrus fruits, and after several years' residence in Florida, the writer ventures the opinion that very considerable areas in the Archipelago are well adapted to citrus culture, and that the chief difficulty consists largely in planting the right varieties and using the stock best adapted to a locality.

There can be no question as to the adaptability of the Batangas mandarin district to the mandarin, but it is a peculiar fact that, at least so far as the writer is aware, with the exception of a few trees of a local citrus fruit known as "tizon," the mandarin is the only species in the genus that produces a really good fruit there. In this region the orange is of mediocre quality, the few lemons and limes are poor, and the pomelos grown are so dry and tasteless as to be inedible from a European point of view. Consequently, when it is remembered that in south Florida, in a similar climate, though a widely different soil, one may find oranges, mandarins, limes, lemons and pomelos growing in close proximity, all of good to very good quality, and when it is also recalled that all Philippine citrus trees are seedlings, it certainly appears extremely probable that the ancestry of our fruits is very largely responsible for the quality, and that, for instance, the Batangas mandarins are of a very good strain while the related fruits in the same region are of poor parentage. Certainly it seems unbelievable that if the strains were equally good, land that produces such superior mandarins should at the same time yield such execrable pomelos and lemons. And, speaking now of other parts of the Archipelago, the fact that individual seedlings here and there bear fruits of good quality, while other trees of the same species in the same section and under the same conditions, bear fruit that is almost inedible, certainly points to the adaptability of the land to the species in question and also to the fact that individuality in seedlings plays a very important part in the quality of the fruit. This in turn serves to emphasize the great importance of budding the seedlings to good varieties.

Insipidity and lack of juiciness are the two cardinal defects in the Philippine citrus fruits, broadly speaking; nevertheless, pomelos of excellent quality have been obtained from Bataan, and we have also reports on good authority that unexcelled pomelos grow in Bongabon, Nueva Ecija, and very well-flavored and juicy limes have been received from Davao and the east coast of Mindanao. In Sumilao, Bukidnon, in the same island, the writer saw, two years ago, a lime tree that was unrivaled

in productiveness, with a fruit on a par in quality with the famous (in the United States) lime from the Florida Keys, lying to the southeast of Florida. In the same town oranges of good flavor and quality were found, though somewhat seedy. These were produced on trees grown from seed imported from Spain. Other oranges and pomelos of Philippine origin in the same town were dry and tasteless. Lemons have been sampled from Masbate that for shape, coloring, thinness of skin, and juiciness, were unsurpassed, but being a seedling strain, they were so bitter as to make them unsalable. If we remember rightly, oranges were received from southern Tayabas a year ago, grown from imported trees that left little to be desired. The fruit of a California Navel orange that has fruited in Manila was even juicier than California grown fruit, its one defect being lack of sprightliness.

In the early days of the Bureau a number of citrus varieties were introduced. A few pomelo and lemon trees remained at the Lamao experiment station when the writer arrived in 1911. The pomelo trees were large and in excellent condition, but have never even bloomed, showing that not all imported varieties may be depended upon to be profitable here. The lemon trees bore a few fruits in 1910 and 1911, but developed gummosis and did so poorly generally that all were removed except one. This has now grown into a tree with a spread of about seven meters and last year carried a fair crop of fruit of fully the excellence of imported lemons. That it is the *variety* and not the *soil* that has here determined the quality is demonstrated by the fact that we have growing, in an adjoining field, under exactly the same conditions, several lemon varieties of native origin that are utterly worthless.

NEW ANNONAS FOR THE PLANTBREEDER.

In the Philippine Agricultural Review for July, 1913, a paper was published by the writer containing a list of 49 species belonging to the family ANNONACEÆ, utilizable for plant breeding work. Mention was then made of the large number of edible species in the genus *Annona,* and it was stated that "it is quite probable that there are several others that when better known may also be found to be of more or less value." Since then three new species have been found that may be of value to the breeder, one of which, as a matter of fact, was described years ago. The description of all has been obtained from "Classification of the Genus Annona, etc." by W. E. Safford, Contr. U. S. Nat. Herb. Vol. XVIII (1914), part 1.

Annona scleroderma Safford. A spherical to oblate fruit, 6.5 centimeters long and 9 centimeters in transverse diameter, with a hard shell, 6 millimeters thick, according to a line-drawing accompanying the description, the surface of which is divided into polygonal areoles by raised ridges. Indigenous to Guatemala.

Most annonas have a soft tender skin and this hard-shelled species is therefore of more than ordinary value.

A. jahnii Safford. A tree 4 to 6 meters tall, of spreading habit. The fruit is ovoid, small, attaining a length of 7 centimeters, muricate, rufously or ferruginously pubescent; pulp edible, sweet, and of pleasant flavor. The species is native to the coastal land of Venezuela and Colombia.

A. globiflora Schlecht. Anonilla. A spreading shrub 1 to 2 meters high. The fruit is small, 3 to 4 centimeters in diameter, spheroid or broadly conoid, muricate or mammilate; the pulp is edible but scanty. The anonilla is native to Mexico.

A. manirote H. B. K. is here considered a synonym of the soncoya, *A. purpurea* Moç. et Sesse, of which a short description appeared in the Philippine Agricultural Review for September, 1914. From the evidence at hand it seems likely that *A. involucrata* Baill. and *A. prestoi* Hemsl. will also in all probability be reduced to *A. purpurea.*

A new genus, *Fusaea,* is established by Mr. Safford, to which he has transferred the pinaioua, *Duguetia longifolia* Baill., an edible, well-flavored fruit originally described by Aublet in 1775.

THE "GIANT" CHERIMOYA.

This is a variety of cherimoya that is being grown to some extent in Queensland, Australia, and which has been reported to bear fruits of excellent quality 2.3 kilograms in weight. In order to obtain an authoritative statement relative to this variety, which was imported two years ago and last year successfully crossed with the atemoya at the Lamao Experiment Station, the writer communicated with Mr. Howard Newport, instructor in tropical agriculture in Queensland, Australia, for information relative to the "Giant." According to Mr. Newport, who courteously sent a photograph of the fruit, while there are no authentic records available, it is believed that the "Giant" is a hybrid between a cherimoya in the Fiji Islands and a large sugarapple. At the Experiment Station in Kamerunga, Queensland, the "Giant" has been found a shy and erratic cropper but of good quality. The photograph received showed a fruit with prominent carpels, weighing 1.2 kilograms, and

Mr. Newport states that he has heard of fruits weighing 1.4 kilograms, which is probably nearly if not quite the maximum weight of this variety. However, an annonaceous fruit of this size is more than sufficient, since a few large fruits have a greater tendency to break the branches of a tree than an equal weight distributed among many smaller ones. Furthermore, small fruits are usually more salable than large ones.

NOTES BY CLEVE. W. HINES, M. S., Station Superintendent.

SUGAR NOTES.

The progressive firm of Alexander and Baldwin of Hawaii has recently added a new official to its personnel with the designation of Auditing Chemist. The duties of this functionary will be somewhat varied but in general will be to give advice to the plantation managers on the various questions arising in the different lines of his duties. His further duties will be to plan and supervise field experiments in addition to his regular work about the mill and with sugars.

It is announced that Mr. S. S. Peck, the eminent chemist of the Hawaii Planters' Association has been named for this position.

Machinery of the very highest efficiency is rapidly replacing the antiquated designs in many of the sugar-houses of Cuba and it is largely on account of this progressive spirit that such remarkable results are secured in their factory workings. It is interesting to note in this connection that every province except Havana contains one or more mills equipped with grooved rolls of the Messchaert type.

An item of very great expense to the sugar producer is the harvesting of his crop. Many machines have been designed to accomplished this task at a decreased cost but each of these failed in some particular or other until, during the past year, it was announced that the Luce cane-harvesting machine has been proven a signal success under Louisiana conditions.

It is claimed that this machine will cut, strip and top from 150 to 200 tons of cane per day and handle very satisfactorily even reclining cane.

Mauritius has long been noted for its production of sugar, but it is only of recent years that renewed interest has been shown in this industry and special efforts put forth with a view to the manufacture of high grade sugars directly from the plan-

tation. This is now accomplished by the use of the phosphoric and sulphurous acid methods.

The sugar industry of Argentina has grown to such magnitude that in 1913 more than two hundred and seventy six thousand tons of sugar were made. The rendiment for that year was 8.8 as against 6.9 the previous year. There are located in Argentina 42 sugar factories of which 38 were being operated in 1913.

The acid-thin-juice process used in connection with the carbonitation system as elaborated by Harloff has given excellent satisfaction in Java and many other countries. This or a similar method could be installed to very great advantage in factories of the Philippines which now make test sugar. They would thus be able to reap the benefits of a better product for direct consumption instead of bearing the expense of transporting their low grade sugar to the States, refining it there, and returning it to these Islands besides paying the middlemen's and agents' profits.

NOTES BY H. O. JACOBSON, Chief of Plant Industry Division.

COÖPERATION.

In recent years we have become familiar with the word "cooperation," particularly with reference to its application in agricultural activities.

In current news we learn that in the United States of America there are today at least 8,500 agricultural coöperative organizations through which, in the year 1914, agricultural products exceeding the huge sum of two billion pesos in value were marketed.

Comparatively young Americans can recall hearing many disparaging and discouraging remarks directed at propositions of this nature, the self-appointed critics confidently asserting that farmers could never learn to do business except individually. But today, in the more notably progresive agricultural regions, the new comer affiliates with the local organization quite as a matter of course.

With but few exceptions, coöperative organizations have resulted because of unstable markets. After a trial with legislation as a corrective measure, the farmers have decided that the remedy must be found among their own number, and organization has begun.

Such organizations, being therefore evolved primarily as defensive measures, have largely retained a rather selfish characteristic which may easily become a weakness.

Naturally, there are two sides to a bargain, and the consumer is at the mercy of the producer except that he can substitute other goods for those he has commonly used.

With a marked tendency on the part of producers' organizations to standardize their product with a view to increase profit only, the consumer is increasingly forced to accept a product that ships well or a better-yielding variety in preference to a particularly meritorious product; besides that, the consumer finds his choice of varieties constantly restricted.

The business world is gradually awakening to the value of service, that is to say, they are beginning to realize the consumers' view point and are learning to coöperate with the consumer.

For that reason, it is well for the producer to remember that the consumer eventually bears the entire burden of the cost and is justly entitled to having his preferences recognized.

ANOTHER SOURCE OF OIL.

The search for oil producing material, accelerated by industrial hunger for a cheaper product to supplant those which in turn have become too expensive because of their utilization as food, has brought to light many varieties of plants which have heretofore been given little consideration.

In the British Trade Journal we learn that in Argentina they have investigated the physic nut, *Jatropha curcas*, finding it drought resistant, not injured by locusts or ants and easily cultivated.

The yield of oil per hectare is said to range from two to three metric tons.

The seed yields 49.3 per cent fat and can be used advantageously in soap manufacture and in pharmaceutical and industrial products.

This plant is widely distributed in the Philippines and thoroughly naturalized, but so far there has been no demand for its seeds.

THE SOIL MINER.

An old definition of the word "farmer" is that he is one who collects taxes. Of late a new term has been used "soil miner."

Seriously considering the question, one must conclude that there are many, indeed, who deserve the title "soil miner."

Consider the average grain grower; he plants seed such as he can readily obtain, and by grace of sufficient sunshine and rain, a crop of grain is produced. He removes the grain and the straw from the field and sells it, converting this material into silver and gold.

In calculating the value of this product, the cost of labor and use of implements enter, but these elements also must be considered in the mining of silver and gold.

By growing the crop of grain, certain amounts of plant foods (minerals) have been permanently removed from the soil, diminishing the productive power of this soil to a certain extent.

Wherein does this type of farmer differ from the accepted type of miner, except in method?

The soil miner type of farmer certainly taxes the soil and future generations.



Yellow Caledonia sugar cane at Alabang Stock Farm. Age 11 months. November, 1914.

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EDITORIAL.

THE PRESENT-DAY SIGNIFICANCE OF ECONOMIC ENTOMOLOGY IN AGRICULTURE.

One of the subjects connected with the science of agriculture which has had a rapid growth within the last half century is the allied science of economic entomology. Synchronously with the development of transportation facilities and the shipment of large quantities of plant material from place to place has occurred the introduction of unheard-of pests from remote regions and well known pests from regions close at hand, while with the advancement of intensive farming and the breeding of early or late maturing varieties of certain crops, has come the apparent increase of native pests brought about by the changed conditions.

In earlier days entomology was looked upon as a pastime for the spare moments of those who cared to turn their attention to it or as a business confined to dusty museums, without any practical application whatever; the true significance of the study was not then apparent. At that time entomology was principally of the kind we now designate as systematic, the pure science as contrasted with the applied, dealing mostly with the structure and classification of forms of insects, much less with their life histories, very little with their possibilities as destructive agents and still less with the matter of waging active warfare against them.

Gradually the practical side developed and has since continued to develop until at the present time economic entomology is recognized by agriculturists as an important adjunct to the study of the actual crop production, without some knowledge of which the cultivator of any plants is likely to meet with obstacles before his harvest is over or his products in the hands of the consumer.

It has been estimated that on the average ten per cent of every crop is a total loss due to the ravages of insect pests. A large part of this damage is so constant, is produced by insects so inconspicuous or hidden, so scattered over large areas or various seasons, that the agriculturist may not know of its

existence, or at any rate, does not figure it other than as a perfectly normal factor in crop production.

On the other hand, there are pests like the locusts here in the Philippines, like the chinch bug of the grain belt of the United States, like the tse-tse fly of Africa, whose depredations are so marked that it is impossible not to recognize them for what they are.

Midway between these two extremes is a vast assemblage of insect pests, some of them constant or of wide distribution, others sporadic or local in their outbreaks, but all of them injurious or capable of becoming injurious. It is with all of these, including both extremes, that economic entomology has to deal, as well as with other insect forms which, although not pests, are yet of practical importance.

The problem is a large one. The number of different species of insects has been placed at somewhat approaching two million. Many of these are very restricted in their habitat; some of them are cosmopolitan. They must be classified and named, for in the knowledge of the relationships of animals very often comes a clue to the best manner of combating them. This is more particularly the work of the systematist but the economic worker must be versed enough in it to know and recognize the forms with which he has to deal. The insects must be reared and their life histories recorded for in the study of the mode of existence of certain pests there is most likely to be uncovered the weakest spot in the defense against which the attack may be directed with greatest success. This is the most essential branch of the study. Exhaustive studies in laboratory and field with parasites and predaceous enemies, studies frequently requiring investigations carried around the world, must be made to determine what natural checks may work upon the pest. The results of meteorological changes to insect life must be understood. Chemicals must be tried out to find their effectiveness as insect sprays, and the possibilities of cultural methods or farm practice for the control of pests must be studied. Finally the results of all this work must be arranged, tabulated, weighed and put before the public.

The questions may be asked, "What good will it do even then? What good has it ever done?" "Are there sufficient benefits to be derived from this work to justify it?" The answer may be found by citing one or two instances.

In 1868 there was introduced into California upon some trees imported from a foreign country, a species of scale insect which spread itself over the state and twenty years later was so

prevalent and abundant that it threatened to destroy the citrus industry of that region. Men were sent out to discover the native habitat of the species and to learn what forces, if any, kept it under control in its own country. It was learned that the scale was a native of Australia and that in Australia a certain ladybird beetle was active in suppressing it. Some of these beetles were introduced, bred and distributed throughout the citrus groves of the state and so efficiently did they operate that the scale was brought under control and has never since become a menace in that region. Here knowledge of the life history, habits and enemies of the insect resulted in saving a statewide industry. Such a system as this, however, works out only under peculiar circumstances.

The Hessian fly is a serious enemy of wheat and where its attacks are pronounced it sometimes destroys whole fields of that cereal before they have much more than begun their growth. A study of the life history of this species revealed the fact that the adults of this fly appear at certain definite seasons, and lay their eggs in the wheat plants. Working from this point it was found that if the wheat is not planted until after the flies have made their appearance, these insects are forced to seek other grasses and by the time the wheat is above ground the danger from this source is past. Adoption of this method of procedure forestalled the crippling of wheat production in certain places.

Some problems are yet unsolved. Owing to ill-timed legislation the fight against the gipsy moth in the New England states was curtailed just as it was reaching a period of control and the effects of delay have never yet been overcome. The campaign against the cotton-boll weevil in the Gulf States is still progressing, and is beginning to show definite results. If recommendations made by entomologists had been followed when first offered, the pest would never have gotten the start it has now. The grape phylloxera in Europe, the San Jose scale in America, the migratory locusts of this country and of other parts of Asia—the warfare against these is continuous and still the pests are present. Nevertheless, if the efforts which are being expended against them should cease, if the assistance which economic entomology has offered were discarded, the result would be an incalculable loss to the agricultural activities of the world. Entomology is no longer purely a diversion or an abstract science, it is an economic, practical and definite science with an application so important and well defined that it ranks second to none among the coadjutants of the world's indispensable industry, agriculture.

HISTORY OF CANE VARIETIES IN THE PHILIPPINES.

By Cleve. W. Hines, M. S., *Station Superintendent.*

Sugar cane was found under cultivation in the Philippine Islands when they were discovered by the Spaniards in 1521, and for that reason no definite knowledge of the introduction of cane growing can be ascertained. From the methods and implements employed in early times, however, it is evident that the industry was introduced from the coast of China.

The history of the cane varieties under early cultivation is even more difficult to trace. It is possible that some of the varieties might have originated here as seedling cane or from bud variations, but it is more than probable that different varieties were brought here from time to time by travelers from other East Indian Islands, and from the Chinese coast.

A small sugar experimental station known as "La Granja Modelo" had been established at La Carlota in Occidental Negros by the Spanish Government, but unfortunately during the period of unrest a few years prior to American occupancy, this station, together with its equipment and many of its records, was destroyed by fire. The few reports still available fail to throw any light on the subject of cane previously under cultivation, or varieties which might have been introduced by that institution.

It is presumed by some that the home of the sugar cane may have been in these Islands, and that some of the large grass-like plants still found growing over various sugar districts are very closely related to that plant. The highest developed of these plants is known as the "Tigbao Mestiza," which was thus named from the fact that it was supposed to be a natural hybrid between the "tigbao," a large grass-like plant, and the sugar cane. This supposed hybrid grows very erect, attaining a height of from three to four meters, and produces a stalk quite small in diameter. The internodes are long and deeply grooved and the stalk is slightly zigzag. The nodes are large, often containing rudimentary rootlets. When mature it contains as high as 9

per cent sucrose and averages about 16 per cent of fiber. Plate No. IV, *a*, shows a view of this cane taken at maturity.

There are a number of cane varieties under cultivation over the Philippine Islands which are designated as "native cane" since they have been under cultivation by the Filipino planters from time immemorial. Many of these vary greatly from each other in their appearance and characteristics of growth. Among the most striking examples may be mentioned the "Inalmon" or "Manila black," which has a very dark color; the "Luzon White," which varies from a green to a yellow straw color, depending upon its exposure to sunlight; the "Negros Dark Purple," which is very dark purple in color and is grown extensively in the sugar districts of the Islands of Negros; the "Cebu Light Purple," which is a light purplish cane extensively cultivated in the Island of Cebu; and the "Striped Leyte," or "Striped Ambos Camarines," which is a striped variety of cane resembling somewhat the striped Singapore, and is grown to some extent in the Island of Leyte and the Province of Ambos Camarines in the southern part of the Island of Luzon. A brief description of the different varieties will be given later in this article.

In the absence of records to indicate the contrary, it is presumed that until recent years no specific attempt was made to introduce into the Islands proved varieties of cane from other countries or to produce seedling varieties here. Indeed it was only comparatively recently that the seed of the sugar cane was found to be occasionally fertile and could be made to produce new varieties. This condition was discovered and the first new varieties were produced almost simultaneously in the year 1887 by Soltwedel in Java and Messrs. Harrison and Bovell in Barbados, British West Indies.

The young plants, when grown from seed, are very delicate and have some resemblance to ordinary grass until they reach the height of several centimeters when they begin to present the appearance of sugar-cane plants.

While many of the native varieties of cane here do not readily arrow, and, of those which do, only a small percentage of the seeds produced have so far been found to be fertile, yet during the past year a number of robust plants were produced here which unfortunately were later mistaken for grass by the workmen employed in the propagation sheds and destroyed. Plans have been made to insure the production of a large number of the seedling plants from both native and imported cane this year,

and thus varieties may be developed which may greatly increase the Philippine production of cane and sugar.

It was only two years ago that a sugar laboratory was established in connection with this Bureau, and a specialist placed in charge in order to further the work of the sugar industry and make a deeper study of the different varieties under observation. Rather than carry on strictly scientific investigations, which are nevertheless very desirable, this Bureau has in the past given its attention to the immediate assistance of planters in improving their methods of manufacture, and in establishing superior varieties of cane from abroad.

In the year 1905 this introduction of cane varieties from abroad may be said to have started. Five varieties were introduced by this Bureau in that year from the Hawaiian Sugar Planter's Experiment Station at Honolulu. The consignment contained cuttings of the following varieties; White Bamboo, Demerara 74, Singapore Striped, Tiboo Mird, and Louisiana Purple. This importation proved more or less a failure and most of the varieties perished before it was possible to learn of their results here.

In February of the year 1910 another consignment of cane was received from the Hawaiian Sugar Planters' Experiment Station and this included three cuttings from each of the following seedling varieties: Hawaii 16, 20, 27, 69, 227, 309. Plate No. II shows views of the original cuttings of these six varieties. These were carefully planted and, as soon as the new cane was large enough, they were cut while immature and planted so as to enlarge the area to such an extent that better observation might be possible as well as to have a sufficient amount of cane in order to carry on chemical analyses with the different varieties (Plate III, *b*). All six varieties were found to do extremely well under conditions here and by the year 1912 it was possible to make small shipments to various plantations in order to get the views of the planters themselves. Previous to the time that the six Hawaiian seedling varieties were received the Lahaina and Yellow Caledonia varieties were introduced from the same place.

Unfortunately the majority of the milling plants at that time were small and of antiquated designs so that difficulty was experienced in milling the large hard varieties, while some difficulty was also encountered with the soft varieties on account of their abnormal size as compared with the native varieties. There were also certain prejudices in the minds of the old local planters against the changing from the old systems, which had

been in vogue for so long a time, to modern ones, and a great deal of practical demonstration work was required to dispel this prejudice against the use of modern cane varieties. It was during this time that larger mills and centrifugal sugar factories were being introduced and with these the improved varieties became very popular. This also aided in stimulating the native planters to accept more extensively the modern varieties of cane, and especially those planters who were to supply cane to the modern factories. Each year since the introduction of these varieties the area has been greatly increased until today each sugar-producing province contains more or less of it, while on one plantation alone more than ten hectares are now under cultivation. It has been found that in many instances more than double and occasionally treble the former amount of cane is secured by the use of these varieties when it is possible to properly irrigate the land. It has been the universal custom in the Philippines to grow sugar cane without the use of irrigation, and in fact few such projects are in operation here today. The modern varieties when grown without irrigation do not produce so well and contain a notable increase in their fiber content, while on the other hand the native varieties fail to respond so readily to the application of irrigation.

Considering that only five years ago but three cuttings of each of the six Hawaiian varieties constituted the start and these were necessarily used in experimental work for some time before it was possible to begin distribution to planters, and even then demonstration work on but a small scale was possible for some time, extremely encouraging results in this direction were attained. This rapid extension of the cane area has been possible by reason of the fact that two cuttings of the crop for planting purposes each year may be made and thus the complete stalk, while yet immature, may be employed for planting under conditions here.

In October of the year 1910 cuttings of Demerara 74, 117 and 1135 were brought over from the Hawaiian Sugar Planters' Experiment Station by Mr. H. J. Gallagher, Superintendent of the La Carlota Experiment Station. The first two varieties were lost from poor germination, but the other, D-1135, survived and has proved a very good variety for certain classes of soils.

In the year 1911 a small consignment of cane was received from Mr. W. G. Taggart, Director of the Sugar Experiment Station at New Orleans, Louisiana, through the Bureau of Insular Affairs, Washington, D. C. This consignment contained the following varieties: Louisiana Striped, Louisiana Purple, Demerara 95

and 74. Since the growing season in that state never extends over a period of more than seven months, it is evident that quick-maturing canes will give the best results with them. Both the Demerara 95 and 74 are extremely early maturers, and the latter in a few years after its introduction into Louisiana became so popular that it largely replaced all other varieties previously cultivated. But this condition of early maturity is just the opposite to what is demanded in a tropical country like the Philippines where the growing season extends over the entire year. Indeed, it has been found in Hawaii that some of their best producers grow for fifteen months or more, which permits the cane to make a much better growth than would be possible in a shorter period. On account of this condition the Demerara 95 and 74 have not proved very successful here, while the Louisiana Purple likewise has always produced but a small tonnage, and has presented a stunted appearance. The Louisiana Striped, on the contrary, has done extremely well and is considered one of the very best imported varieties now in use. This cane has been characterized by a fairly low fiber content and high sucrose and purity while at the same time giving a good yield of cane. On account of the softness of its tissue, this cane has been found to be readily milled in the smaller factories. This softness of the shell, however, gave rise to certain objections some of which are not so much apparent now as they might become some time in the future, should certain insect pests and rodents be allowed to get beyond control. Soft canes are always more susceptible to insect pests, such as cane borer, than are the firmer varieties. Indeed, some of the extremely hard varieties are found to be almost immune to such attacks in countries where the insects are prevalent.

In April of 1911 the next introduction of cane was made when three four-pound parcels of the "Uba," or Japanese forage cane, were received from Chino, California. The original of this cane came to California from Prof. S. N. Tracy of Biloxi, Mississipi. This cane is not used here as a source of sugar, yet it is a closely allied species of the sugar cane. When mature, the juice contains as high as 14 per cent of sucrose, but the fiber content of the cane ranges as high as 15 per cent or more, which makes the cane impracticable as a source of sugar. The glucose ratio in the juice is also quite high, which causes the sugar to be difficult to extract. This cane is, however, used extensively as a forage crop for animals and has proved a very profitable plant for that purpose, since it requires little cultivation, stools well and ratoons almost indefinitely when a suitable soil and sufficient

moisture are provided (Plate III, *a*). It is not uncommon for this cane to produce more than 100 tons of cane per hectare each year under proper treatment and when harvested twice per year, while yet immature. This cane is green or yellowish straw in color when mature with more or less gum which gives it a blotched appearance. It is small in diameter, grows tall, and somewhat erect. The internodes are quite long, regular and contain little or no groove. The nodes are fairly prominent and set with well-developed and pointed buds. This cane germinates extremely well and even when maturity is reached very satisfactory germination often takes place. The leaves are narrow, upright, curving at about 15 centimeters from the point, and are tightly attached to the stalk even at maturity.

In the latter part of the succeeding year, 1912, Mr. H. B. Ross brought from Australia cuttings of the following varieties and presented them to this Bureau; the descriptions by Mr. Ross are given herewith:

Imperial or Striped Cheribon.—A cane distinctly striped in purple and red. The leaves are always variegated. A low-grade cane supposed to be a sport of Cheribon.

Cheribon.—Bright-red cane with long joints. A cane yielding a small per cent of sugar, but a large yield of cane per unit area. Considered a low-grade cane.

Hambledon Seedling—Queensland No. 426.—Light-purple cane, very drought resistant. Has a high sucrose content. Matures early; usually from 9 to 12 months are required. This cane was received from the Government Experiment Station at Mackay, Queensland.

Hambledon Seedling—Queensland No. 426 (Sport).—This is a long-jointed purple cane, giving a heavy yield of cane. Considered a low-grade cane.

Hambledon Seedling—Queensland No. 5.—A light-red cane very similar in appearance to Demerara 1135, but larger. Looked upon as a very satisfactory cane in Australia.

Otomato or Striped Cheribon.—An almost black cane with one purple stripe running longitudinally. Yields heavily in cane, but contains low sugar content.

Mauritius Seedling No. 1900.—This is a bright-red cane which matures early and yields well in sucrose.

Mauritius Malagache.—This is a dark-purple cane with long internodes. It matures in about 12 months. Yields exceedingly well in both sucrose and cane.

Malabar.—This cane is red to green in color; the outer tissue

cracks readily in the sun. It yields well in cane, but contains a low per cent of sugar.

Whitcaloram.—This is a dark purple or almost black cane with very long joints. When mature the outer tissue presents a sun-cracked appearance. It is a very strong cane and grows extremely erect. On this account it is sometimes used as a hedge outside of cane fields. Its sucrose content always runs low.

New Guinea No. 24.—This is a light-red cane which yields a high percentage of sugar when ripe. Care must be exercised that this cane be not cut before maturity, otherwise it dies without producing a ratoon.

New Guinea No. 24–A.—This is a light-green cane, maturing in about 12 months, and yields well.

New Guinea No. 24–B.—This is a dark-green cane with red stripes, maturing in about 12 months. It is a heavier yielder than 24–A.

Badila or New Guinea No. 15.—This cane varies from light to dark purple in color. Contains a high sucrose content. It is a late cane requiring from 12 to 15 months to mature.

New Guinea No. 40.—This is a striped cane resembling somewhat the Louisiana striped cane in appearance, except that the stripes are red and yellow of a shade similar to the Spanish National Colors. It is a late cane maturing in about 15 months and has a high sucrose content.

Barbados Seedling No. 3141.—This cane has a dark-green color and contains a high sucrose content.

The above description of varieties may not coincide exactly with the description of the same varieties now being prepared with the cane growing under the conditions and environments of this country, which sometimes make a material change in the characteristics.

During the latter part of the year 1912, the Mindoro Sugar Company imported from Hawaii a number of seedling varieties of cane and also the Striped Mexican. About the same time the seedling variety, Java 247, was received by them from Java and has since been propagated to such an extent that quite a large area is at present under cultivation on their estate. Through the courtesy of Mr. Geo. H. Fairchild, manager of that company, a consignment of the Java No. 247 cane was received by this Bureau during the latter part of the year 1913. This cane has since been growing at the Alabang experiment station and so far has given such encouraging results that it bids fair to become a popular variety here in the Philippines.

This cane varies in color from purple to a dark brown. It is very firm and resists windstorms well.

In October, 1913, two varieties, the Chinois and Big Tana, were received from Saigon. Since the original planting of this cane was so small and difficulty was experienced in starting these plants, it has not been possible to secure much data on their results here up to the present time, but during the coming year definite results will be possible since the area has now been increased to such an extent that this work may now be carried on.

The most recent importation of foreign varieties arrived in October of the present year from the sugar experiment station at Pasoeroean, Java. This consignment included the following varieties with their descriptions quoted herewith:

No. 100 P. O. J.—This is a yellow or brownish cane which does best on an aerated soil with sufficient moisture. It gives a low yield of cane but contains a high percentage of sugar. It matures quickly and is considered the second-best variety.

No. 213 P. O. J.—This is a brown-colored cane which contains a high percentage of fiber, but gives a good quality of juice. It even grows in soils which suffer from overflow and from drought.

No. 247–B.—This is a red cane now the chief variety of Java and gives a high yield of cane but contains a low percentage of sugar. It matures in Java in thirteen months.

No. 826 P. O. J.—This is a red-colored and strong cane. It is new but is considered very good.

No. 979 P. O. J.—This is a green-colored and strong cane. It is new, but is considered very good.

Black Cheribon.—This is the old cane of Java and gives a very good juice.

Unfortunately, this last consignment of cane was for some reason delayed in transit and more than three months elapsed from the time of cutting until the points were planted. On this account they were so badly deteriorated that little or no hope was entertained of any germination, but at this writing two of the varieties, No. 213 P. O. J. and Black Cheribon, are begining to show signs of growth and may possibly survive. A duplicate shipment has been requested of these varieties which, it is hoped, will arrive in good condition.

DESCRIPTION OF NATIVE VARIETIES.

Inalmon or Manila Black.—This cane has been grown to some extent in various parts of the Islands of Luzon and Negros.

It is charactized by a very dark outer tissue which distinguishes it from any other variety under cultivation here. After this dark covering has been almost entirely removed by scraping, there is enough of the soluble coloring matter (anthocyan) remaining to impart a red color to the water when the scraped stick is immersed. This cane has a very soft tissue and a fiber content ranging from 10 to 11 per cent, depending upon the conditions under which it was grown. The juice is usually high in sucrose and purity when the cane is fully mature and on account of this condition together with the fact that it has a very soft tissue and has a distinctly agreeable flavor, it has always been a favorite cane for chewing by the Filipinos. This cane grows quite rank when planted on rich moist land, but it is usually very recumbent and sometimes badly matted together at harvest time on account of its soft tissue. There is in some localities, however, a variety of this cane with marked resemblance to the one just described, except that the tissue is more firm and the cane stands more erect at maturity. It is possible that this is the same identical cane with different characteristics caused by the change in environment. The dead leaves of both of these varieties drop off as the cane ripens and leave the lower portion of the stalk quite bare.

Luzon White.—This cane varies from a greenish yellow to a straw color and is extensively grown on the low humid portions of the Island of Luzon. It does best in a rich soil with plenty of moisture, in which condition it produces a very large tonnage but does not contain a high sucrose percentage. When this cane is planted on poor soil with a scanty supply of moisture, the yield is very much diminished and the fiber content materially increased. The fiber content ordinarily runs slightly higher than in the Inalmon or Manila Black. The leaves of this cane are large, wide and usually recumbent with the leaf sheath tinted purple. This is a soft cane, and on account of this quality it has been quite popular as a cane for chewing and for use in small native mills in the regions where it has been grown.

Negros Dark Purple.—This cane bears its name from the fact that it is extensively grown in the Island of Negros which is the most important sugar-producing section of the Philippine Islands. The color varies from a light to a very dark purple, depending upon the stage of maturity and the exposure of the cane to the sun's rays.

It is a soft cane and for this reason is seldom found erect at the time of maturity, except when grown in protected localities. The fiber in this cane usually runs low, averaging from $9\frac{1}{2}$ to 11

per cent at the time of maturity. The internodes are fairly long and contain a deep groove which quite often extends the full length. The concave surface of the groove is ordinarily green in color. This cane stools well when a bountiful supply of moisture is supplied and at the same time it grows much larger, but the percentage of sucrose is materially decreased, while on lands which have been cropped to sugar cane for a number of years and have not yet reached the stage of exhaustion, it produces fairly well in cane and contains a high percentage of sucrose. On the other hand, when this cane has been planted on more nearly exhausted soils, like those in the vicinity of Manila which have been grown to sugar cane ever since the introduction of the industry here, a lower yield has been obtained and the fiber content has run comparatively higher.

Cebu Light Purple.—This is a light-purple variety of cane which is grown extensively in the poor soils of the Island of Cebu and certain portions of Luzon. It does better on partly worn soils than any of the other native varieties. This cane is characterized by a very high sucrose content occasionally running beyond 17 per cent. The yield of this cane, however, is usually small in the region where it is now planted, but when grown in more fertile soils with an abundance of water, it grows larger and throws out more stalks to the stools, thus materially increasing the yield, while at the same time it contains a lower percentage of sugar. This cane is very soft and is quite popular in the regions where it is now grown, since most of the native mills are small and of such antiquated design that extraction of juice can only be accomplished with a small soft cane. The internodes of this cane are short, except when the cane is grown in good soil. The leaves are quite large, stand somewhat erect and vary from a light to a dark green color with a pinkish tinted leaf sheath.

Leyte Striped or Ambos Camarines Striped.—This cane contains stripes of red and yellow or yellowish green and resembles somewhat the Singapore Striped except that it usually grows smaller in diameter and contains longer internodes. It has never been a very popular sugar cane from the fact that it contains a low percentage of sucrose and is more difficult to mill than many of the other native varieties.

A BRIEF DESCRIPTION OF SOME OF THE FOREIGN VARIETIES GROWING IN THE PHILIPPINES.

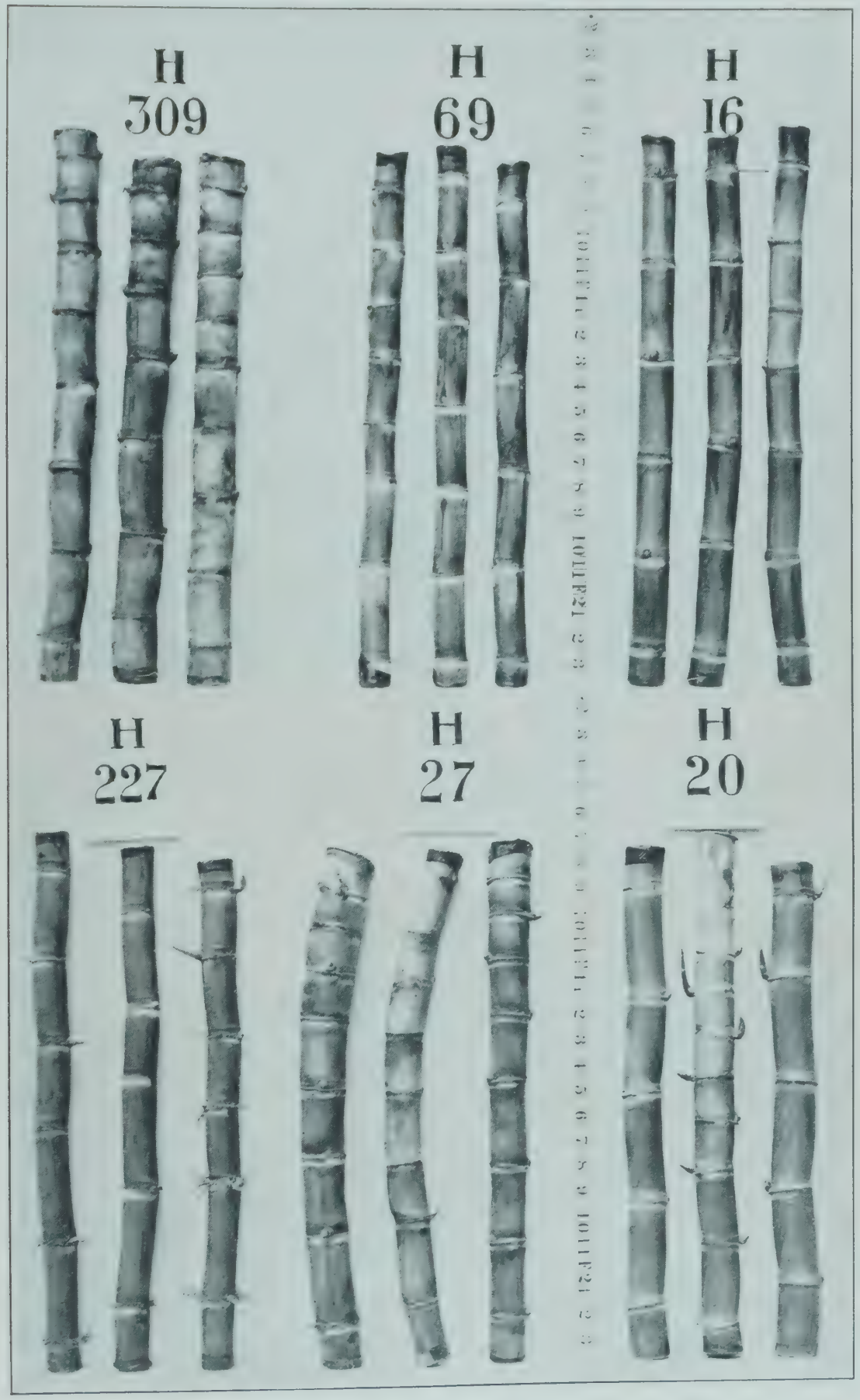
Hawaii 16.—This is a large dark-green cane with a rosy tint and a gummy appearance. It has a soft tissue and has been one of the favorite imported varieties with the native planters.

The internodes are fairly long, somewhat zigzag and contain a very slight groove. The nodes are of medium size and contain a light-colored ring where the leafsheath is attached. The buds are small and flat. The fiber content of this cane averages from 10 to 13 per cent and the juice is of a fair quality. This cane arrows profusely at the age of 11 to 12 months and contains a fairly small, spreading plume. The yield of cane and recoverable sugar is about the average for the imported varieties, this being governed largely by the condition of the soil and treatment given the cane.

Hawaii 20.—This is a light-green cane with a slightly rosy tint turning to straw color at maturity and when exposed to the sun. It is a very hard cane and grows extremely erect, resembling somewhat the yellow Caledonia except that it has longer internodes and is not so subject to splitting during rapid growth. The internodes are slightly concave and zigzag. The nodes are prominent with a pinkish tint at the ring where the leaf sheath is attached. The eyes are small and round. This cane contains from 11 to 13½ per cent of fiber and gives a juice with a fair sucrose content and purity. The yield of cane is large, and the juice is of a very good quality. This cane arrows profusely at the age of 11 or 12 months, giving a slender, fairly long plume with a long stem.

Hawaii 27.—This is a very large dark-green cane changing to a rosy tint at the upper internodes, and has a very slight gummy surface. It is but medium hard and grows erect. The internodes are fairly long and slightly zigzag. The nodes are prominent with buds which are small, yet full and round. The fiber content ranges from 11 to 13 per cent. The juice has a fair sucrose content and purity coefficient. The leaves are long and fairly erect. At the age of about twelve months this cane arrows, forming a large, open, spreading plume. This variety has given but a fair yield in cane and has not proved as favorable for the native plantations as the No. 16 and No. 69 varieties because of its fairly hard tissue.

Hawaii 69.—This is a large green cane with a rosy blush along the stalk and has a very dirty, gummy appearance. The latter characteristic is very noticeable with this variety. The tissue is soft causing the cane to be more or less recumbent. The leaves are narrow, erect and have a midrib with a greenish tint. The internodes are of average length and fairly straight. The nodes are somewhat large and set with small, flat buds which lie close to the stock. The fiber content averages from 10.5 to 13 per cent. The sucrose percentage and purity coeffi-



Original cuttings of six Hawaiian seedling varieties of sugar cane received by the Bureau of Agriculture from the Hawaiian Sugar Planters' Experiment Station in February, 1910.



(*a*) Uba (Japanese Forage Cane) at Alabang Stock Farm. Age 10 months. November, 1914.



(*b*) Six Hawaiian seedling varieties of sugar cane growing at Alabang Stock Farm. Age 12 months. December, 1912.



(*a*) Tigbao Mestiza Cane grown at La Carlota Experiment Station. Age 12 months. December, 1915.



(*b*) Arrow (plume) of the Louisiana Striped sugar cane, grown at Alabang Stock Farm. December, 1914.

cient of the juice have, so far, not been very encouraging, as likewise the yield of cane. It produces small, open, but spreading plumes.

Hawaii 227.—This is a fairly small straw-colored cane with a slightly rosy tint near the top and a gummy appearance all along the stalk. When exposed to the sun the main stalk often contains blotches of a blood-red color. This cane is hard and grows very tall and erect. The internodes are fairly long, slightly zigzag and contain a prominent groove. The nodes are large and set with small round buds. The leaves are narrow and stand erect, but curve near the tip. Open spreading plumes of a dull ash color form at the end of about 11 months. This cane stools fairly well and yields well in cane but the sucrose content and purity of the juice are rather low. It ranges in fiber from 11½ to 13 per cent.

Hawaii 309.—This is a very large, dark-green cane with a rosy tint on its upper portion, and a gummy appearance over the main stalk. It is fairly hard and grows quite erect. The internodes are of average length, slightly zigzag and grooved. The nodes are large, dark in color, and set with small pointed eyes. The leaves are broad and stand fairly erect, curving at about 20 centimeters from the end. This cane arrows at the age of 11 or 12 months, forming large wavy plumes. The yield of cane is above the average for the imported varieties, and it contains a juice of a very good sucrose content and purity coefficient. The content of fiber ranges from 11 to 13½ per cent.

Yellow Caledonia (Plate I).—In size this is one of the largest varieties of cane grown in these Islands. It yields better in cane than any of the other varieties when grown on rich soil with sufficient moisture and produces well even in low wet lands subject to overflow. This cane grows somewhat erect and resists windstorms well because of the hard outer tissue. The color is green, turning to yellow or straw color and, when exposed to the sunrays, a reddish appearance is taken on. The internodes are long, concave and somewhat zigzag. They often crack or split at or near the time of maturity, especially when the cane has been growing very rapidly. This condition causes a noticeable decrease in the percentage of sucrose and coefficient of purity. The nodes are large and prominent. They often contain rudimentary rootlets which have a purplish color when the leaf sheath is removed. The buds are small, flat and poorly developed. The fiber content runs from 11 to 14 per cent or even higher due to the fact that the cane often has a pithy center which contains very little juice. The leaves are long and broad with a conspicuous

white midrib. This cane arrows profusely at the age of 11 or 12 months under conditions in these Islands. The plume is of a dull gray or ash color and has large spreading branches.

Louisiana Striped.—This is a red and yellow striped variety of cane in which the colors vary to some extent according to the conditions under which it was grown. Instead of yellow the stripes are sometimes of a green color. This is more especially the case when the cane is yet immature. This variety of cane is soft and does not stand the tropical storms well. Another reason for this condition is that it grows quite tall. The internodes are long when the cane is grown in good soil. The groove is of moderate size and occasionally extends the whole length of the internodes though usually it extends but half the length. The fiber content ranges from $10\frac{1}{2}$ to 13 per cent. The leaves are medium broad and quite erect. This cane arrows profusely at the age of 11 or 12 months with a fairly open but medium-sized flower (Plate IV, *b*).

Rose Bamboo.—This is a small or medium-sized cane of a green color usually having a rosy blush all along the stock. It is a medium-soft cane and for this reason is usually recumbent. The internodes are of medium length and are usually grooved the full length. The nodes are fairly large and set with small round buds. This cane arrows at the age of 11 or 12 months, giving a long spreading plume. The fiber content ranges from 11 to 13 per cent. The juice contains a fair sucrose content. This cane has never been looked upon as one of the important varieties here owing to the fact that the yield is not large.

Lahaina.—This is a medium-sized cane of a green color except when exposed to the sun, in which case it turns straw color or yellow. It is very soft and is seldom found erect at the time of harvest. The internodes are very long with a well-defined groove. The nodes are fairly large with a wide ring and often contain rudimentary rootlets showing a white ring when the leaves are removed. The buds are large and well developed. The plume is small and spreading. The fiber content of this cane ranges from $10\frac{1}{2}$ to $12\frac{1}{2}$ per cent. It gives a juice of a high percentage of sucrose and coefficient of purity, but the yield in cane has been slightly below the average of the imported varieties.

The above description of cane varieties is based on observations taken here in the Philippine Islands in which climatic conditions are such that cane reaches maturity at the end of 12 months when planted just after the close of the rainy season. When cane is

planted late in the season, it occasionally happens that those varieties which ordinarily arrow, fail to do so under prevailing conditions and fail to reach a natural state of maturity, hence, they contain a greater percentage of fiber and give a juice with a lower sucrose percentage and purity coefficient.

The "Louisiana Striped" variety when grown under conditions here in these Islands produces, at the end of one year, a fairly open but medium-sized plume of a dull-ash color. The sucrose content of the cane and purity coefficient of the juice are each very satisfactory yet when grown in Louisiana this cane never arrows and contains a much inferior juice. This is, of course, due to the fact that cane reaches full maturity here, while there it is never permitted to grow more than seven months on account of the cooler climate.

FIELD AND LABORATORY TRIALS.

To obtain comparative results on the different varieties under observation, a level tract of land of uniform composition was secured at the La Carlota experiment station in Occidental Negros late in 1912. It was prepared and planted to the different varieties under strictly uniform conditions. The cane was cut into lengths containing two or three good buds each and only the upper or immature portion of the stalk was used for this purpose. The rows were placed $1\frac{1}{2}$ meters apart and the cane planted three points to the meter, being set at an angle of about 45 degrees from horizontal. As sugar cane matures in about 12 months in the Philippines, this cane was ready for cutting in the following December and January, these being the months in which the cane harvest usually begins.

In carrying on investigation work with the different varieties, a large sample consisting of average stalks is collected once each week and immediately analyzed. The juice is extracted by means of a laboratory mill, giving an average extraction of 67 per cent of the weight of the cane. The fiber is determined by the hot-water diffusion process in which a temperature of 80° to 100° C. is reached before each expulsion. After five extractions the fiber is dried to constant weight.

The total solids of the juice are determined by Brix spindles carefully calibrated at $27\frac{1}{2}$° C., that being the standard temperature for tropical countries. In order to give results in a tabulated form which would be comparative with those obtained from the several factories scattered over the different sugar regions, direct polariscopic readings, using Horne's dry-lead subacitate

as a precipitate, have been employed. For other purposes the Clerget or invert-reading method has been employed, using the following formula to compute the results:

$$S=\frac{100\ (P-I)}{142.66-\frac{T}{2}}$$

Glucose is determined by the volumetric method using Soxhlet's solution.

Analytical work on the cane varieties is started about one month before the opening of the milling season and is continued to about one month beyond the close of that season. This usually is from November to March. A tabulated list of some of the more promising varieties of cane now under observation is included at the close of this article and a description of these cane varieties is given on the preceding pages.

SELECTION OF CANE VARIETIES MOST PROFITABLE TO CULTIVATE.

In the selection of the most profitable cane variety to be cultivated a great many factors must be taken into consideration. Among them may be mentioned the sucrose content of the cane, purity of the juice, fiber content of the cane, the yield of the cane, and the yield of available sugar. This latter factor is one of the most important to the sugar producer as it shows the amount of the finished product to be obtained. A very convenient formula for computing the available sugar from the extracted juice is as follows:

$$\left.\begin{matrix}\text{Weight of total sol-}\\ \text{ids in the juice.}\end{matrix}\right\}\times 100-\left\{\frac{100-\text{Purity of juice}}{100-\text{Purity of exhausted molasses.}}\right\}=\text{Available sucrose.}$$

Ordinarily when cane is to be milled in a large modern factory the hard varieties answer as well as the soft from the extraction standpoint. Therefore this point need not cause any concern. These hard canes have a distinct advantage over the softer ones in regions where such insects as cane borers are prevalent, or where damage by rodents occurs, since they offer more or less resistance to these attacks. There is also less labor required in harvesting such varieties since they stand more erect and do not become so tangled and twisted during storms. On the other hand, where the crushing plants are small and imperfect, it is impossible to secure a good extraction with these varieties and consequently in that case the softer varieties answer better.

Average analyses of cane juices from varieties growing at the La Carlota experiment station, Occidental Negros, 1914–1915.

(Extraction juice on cane 67 per cent.)

Month.	Weight of stalk in kilos.	Brix.	Sucrose.	Purity.	Glucose.
Hawaii 16:					
October	1.90	14.80	11.48	77.56	1.370
November	1.37	15.45	12.70	81.98	1.005
December	1.40	16.47	14.25	86.52	0.680
January	1.58	15.68	13.36	85.20	0.660
February	1.49	15.77	14.10	89.41	0.510
March	1.75	13.55	11.38	83.98	0.500
April	1.75	17.45	15.37	88.08	0.610
Hawaii 20:					
October	1.77	16.70	13.98	83.71	0.806
November	1.48	18.90	16.35	86.50	0.640
December	1.33	18.40	15.95	86.68	0.580
January	1.61	16.66	14.40	86.43	0.476
February	1.43	14.80	13.35	90.20	0.500
March	1.44	14.80	12.20	82.43	0.660
April	1.38	16.85	14.50	86.05	0.420
Hawaii 27:					
October	2.09	15.30	12.02	78.56	1.070
November	1.87	17.05	14.10	82.69	0.720
December	1.25	16.20	13.45	83.02	0.730
January	1.73	17.16	14.50	84.49	0.550
February	1.81	17.40	14.90	85.63	0.480
March	2.21	17.97	15.25	84.86	0.630
April	2.15	19.55	17.12	87.57	0.400
Hawaii 69:					
October	1.64	15.30	11.95	78.10	0.860
November	1.32	16.60	13.40	80.72	0.670
December	1.23	15.30	12.30	80.39	0.785
January	1.39	15.32	12.10	78.98	0.690
February	1.26	15.10	11.95	79.13	0.657
March	1.62	16.55	12.97	78.36	0.580
April	1.48	16.10	13.07	81.18	0.245
Hawaii 227:					
October	1.61	15.86	12.34	77.17	0.950
November	1.53	17.37	14.40	83.47	0.717
December	1.16	17.00	11.20	65.88	0.660
January	1.38	16.90	14.20	84.02	0.440
February	1.40	17.37	14.90	85.78	0.470
March	1.61	17.70	14.90	84.18	0.510
April	1.44	18.45	15.67	84.71	0.410
Hawaii 309:					
October	2.35	16.57	13.68	82.55	0.886
November	2.14	17.67	15.05	85.11	0.75
December	1.94	17.07	14.35	84.06	0.62
January	2.20	17.45	15.20	87.10	0.45
February	1.79	17.70	16.35	92.37	0.43
March	2.00	18.50	15.15	81.89	0.40
April	2.33	17.60	15.42	87.73	0.35
Yellow Caledonia:					
October	2.00	15.44	11.70	75.77	1.210
November	1.83	16.70	13.65	81.73	0.810
December	1.26	16.35	13.25	81.03	0.730
January	1.53	17.10	13.85	80.99	0.620
February	1.36	18.40	15.47	84.07	0.510
March					
April	1.41	16.57	13.12	79.17	0.510
Louisiana Striped:					
October	1.53	17.08	14.24	83.37	0.920
November	1.25	18.70	16.40	87.70	0.468
December	1.32	18.82	16.80	89.26	0.370
January	1.42	18.90	16.88	89.31	0.398
February	1.23	19.95	16.70	83.70	0.400
March	1.20	19.75	17.17	86.93	0.690
April	1.25	20.07	17.90	89.18	0.440
Rose Bamboo:					
October	1.46	16.48	14.00	84.95	0.740
November	1.47	17.20	14.20	82.55	0.510
December	1.15	15.90	14.80	93.08	0.540
January	1.46	16.30	14.00	85.88	0.410
February	1.50	16.37	14.50	88.57	0.420
March					
April	1.41	19.05	17.37	91.18	0.260

Average analyses of cane juices from varieties growing at the La Carlota experiment station, Occidental Negros, 1914–1915—Continued.

Month.	Weight of stalk in kilos.	Brix.	Sucrose.	Purity.	Glucose.
Formosa:					
October	1.42	16.58	13.20	79.61	0.860
November	1.56	18.70	16.00	85.56	0.647
December	1.90	17.20	14.80	86.04	0.480
January	1.42	16.90	14.58	86.27	0.500
February	1.54	18.45	16.50	89.43	0.380
March	1.50	19.75	17.90	90.63	0.570
April	1.51	18.82	16.47	87.51	0.260
Chinoise 3526:					
October	1.26	16.70	14.20	85.02	0.570
November	1.10	16.90	14.50	85.79	0.557
December	1.54	15.88	12.90	81.23	0.880
January	1.30	19.40	17.00	87.62	0.190
February	1.26	19.60	14.74	75.20	0.210
March					
April	1.05	21.15	18.70	88.41	0.240
Louisiana Purple:					
October	1.54	15.88	12.90	81.23	0.886
November	1.10	16.90	14.50	85.79	0.557
December	1.26	16.70	14.20	85.02	0.570
January	1.20	16.20	12.40	76.54	0.487
February					
Lahaina:					
October	1.73	19.10	16.87	88.32	0.420
November	1.32	19.67	17.45	88.71	0.345
December	1.37	19.47	17.54	90.08	0.217
January	1.27	17.78	15.68	88.18	0.338
February	1.40	18.07	17.07	94.46	0.260
March	1.31	18.07	16.7	92.41	0.400
April	1.40	20.22	18.57	91.83	0.260
Inalmon or Manila Black:					
October	1.58	17.40	15.04	86.43	0.730
November	1.39	18.70	16.50	88.24	0.405
December	1.07	18.45	16.67	90.35	0.315
January	1.33	17.23	15.50	89.69	0.368
February	1.38	17.85	15.82	88.62	0.407
March	1.49	16.47	13.85	84.09	0.620
April	1.56	18.97	17.10	90.14	0.230
Negros Purple:					
October	1.19	16.04	13.10	81.67	0.998
November	1.04	17.87	15.60	87.29	0.470
December	1.06	19.35	17.60	90.95	0.270
January	1.23	18.20	16.08	88.35	0.390
February	1.28	19.60	17.57	89.64	0.480
March	1.29	18.90	16.86	80.20	0.560
April	1.42	20.10	17.40	86.56	0.400
Cebú Light Purple:					
October	1.32	13.88	10.60	76.36	1.290
November	1.15	15.55	12.80	82.31	0.760
December	1.12	17.50	15.80	90.28	0.530
January	1.37	18.80	16.68	88.72	0.380
February	1.28	10.80	17.60	89.79	0.280
March		20.47	18.15	88.66	
April	1.60	18.45	16.10	87.26	0.310
Luzon White:					
October	1.50	16.10	13.70	85.09	0.720
November	1.22	17.02	14.70	86.36	0.530
December	1.20	17.35	15.50	89.33	0.308
January	1.20	17.68	14.60	82.57	0.280
February	1.35	18.65	16.30	87.39	0.250
March		18.97	17.00	89.61	
April	1.35	18.92	16.72	88.37	0.390

The above represent an average of composite samples taken each week during the respective month.

A FEW FACTORS IN INSECT CONTROL.

By JOHN T. ZIMMER, *Acting Superintendent of Pest Control.*

Insects may be divided into the following three general groups, according to their relationship with man: beneficial, neutral, and injurious.

The first group includes those forms which are of service to man either directly, such as the cochineal insect, the silkworm moth or the honey bee which furnish products useful to man, or more indirectly, such as the various wild bees, moths, beetles and other forms which pollinate flowers and aid in the production of fruit, such as the scavengers which destroy rotting material which might otherwise spread disease, and the parasites and predators which, in common with man, wage warfare against the pests.

The neutral insects are those which devote their attention to plant and animal forms which man does not find either serviceable or injurious and with the development of which he is not interested except in a purely scientific sense.

The injurious insects are those which by their depredations cause economic losses to man. These depredations are widespread, and may be upon field crops, upon economic products such as cigars, furniture or woodwork of other kinds, upon growing timber, or upon man himself, either as a direct parasite or as a carrier of disease. The depredations may be in the nature of secondary parasitism, that is, attacks upon forms which as primary parasites are attacking other insects and which in this particular case are helping in the control of pests.

None of these groups are stable. Insects which may be beneficial in one stage of their existence may be injurious in another. For instance, certain of the blister-beetles found in America feed as larvæ upon locust eggs, but when they themselves reach adult development they turn their attention to alfalfa and cause severe injury thereto. Other species may be injurious only under certain conditions as, for example, the rice bug of this country which feeds normally upon various wild grasses but

attacks rice when the latter is grown in regions inhabited by the bug. Certain predatory insects feed alike on injurious, neutral, and beneficial forms and automatically become beneficial, neutral or injurious accordingly, depending on the preponderance of activity.

Nevertheless, certain insects have very definite tendencies and occupy a fairly constant position which is very readily determinable, either as friends or enemies. Those which are enemies are, perhaps, better known to the average farmer than those which are friends, but although he must learn to recognize the beneficial forms and protect them he must also learn to distinguish the enemies and find out how to combat them.

A certain amount of insect damage is purely mechanical, such as the breaking down of bamboos and standing grain by locusts which settle upon them. A certain portion is also connected with the breeding habits of the creatures, such as the slitting of twigs of trees by cicadas to form receptacles for egg deposits, the girdling of stems by twig pruners so that the larvæ of the pest may have suitable places to work when they hatch, or the mutilation of leaves by certain ants and bees in their search for building materials for their nests. Nevertheless, the greater amount of destruction is the direct result of the insects feeding or searching for food.

Setting aside the exceptions here mentioned we may subdivide the insect pests into two general groups based on the manner in which their food is obtained, in other words, on the character of the anatomy of the mouth parts. Aside from a few cases where the adults have atrophied mouth parts and take no food after they become imagoes, such as the Mayflies and bot flies, insects have mouth parts fitted for biting or for sucking. One type may be present in the larvæ and the other in the adults of a single species as in the butterflies and moths, or they may be combined in one as in the bees. The forms with jaws usually procure their food by removing particles of the plant and either chewing and swallowing these pieces or squeezing them between their jaws and swallowing the juice. A notable example of the latter is found in the adult of the common uang or rhinoceros beetle which attacks the coconut trees. The forms which have sucking mouth parts may sip exudations as do the butterflies and moths, in which case they are scarcely injurious; they may, as do the maggots of certain flies, attach themselves to the host and absorb the juices through the surface; or they may, as do the plant lice and scale insects, force their beaks beneath the surface and suck their food therefrom without ab-

sorbing any surface particles. This is a feature which is of extreme importance when it comes to the matter of applying poisons to control insect attacks.

There is no part of a plant that is safe from the ravages of pests—roots, trunks or stems, branches, foliage, flowers or fruit, pith, bark or heartwood; all may be affected and by insects with either suctorial or mandibulate mouth parts. Some of the pests may be external feeders living on the surface of their host plants, feeding entirely on surface matter or sometimes boring short distances into the interior as in the case of the rhinoceros beetle or as in the curculios and bill bugs, whose attack resembles somewhat that of the sucking insects. Some of them may be true borers, passing at least one stage of their existence wholly within the interior of the plant they infest. These latter sorts include the particular forms which bore between the surfaces of leaves and which are known by the distinctive term "leaf-miners." The borers are all more difficult to attack than the purely external feeders since they are often inaccessible unless the plants or parts of the plants have first been destroyed. Likewise the sucking insects offer difficulties due to the fact that their food cannot be poisoned in such a way that they will eat the treated portions. Spraying for these pests must be done by applying washes or solutions which operate caustically or poisonously upon the integument or in the tracheæ of the insects with which they come in direct contact. Frequently the insects which it is thus desired to attack are of such constitution that any spray which is strong enough to have the desired effect on them will seriously injure the plants on which they are feeding. Thus, in many cases, unless the pest is present in small isolated groups which may be profitably destroyed along with their host plants to the end that the remainder of the fields may be safe from attack, spraying with "contact poisons" is quite out of the question.

Means of control of insect pests may be roughly classified as insecticidal or preventive. The insecticidal treatments embrace those types which result in the death of the pests; preventive, those which avert insect attack either by driving the pests away when they make their appearance, or by making their hosts inaccessible or distasteful to them.

As roughly classified, we may include natural enemies among the insecticides. These are parasites, predaceous animals, diseases, and those mechanical forms of control such as hand picking or collecting, trapping, exposing to the action of weather or to extremes of temperature, inundation, etc. More partic-

ularly the term is restricted to the application of artificial remedial measures such as poisons or corrosive mixtures, or fumigants. The poisons may be applied directly to the food plants of the insects, coating these in such a way that in order to obtain food the creatures must absorb some of the poison into their systems. The poisons must therefore be applied in strengths which not only will have no injurious effect on the plants but will not be so distasteful to the pests that the latter will refuse to eat the treated material. Yet the insecticide must kill the pests or render them helpless when they do eat it. In other cases these "stomach poisons," as they are called, may be used to poison baits which are offered to the pests and which are made so attractive by one means and another that the insects prefer them to, or find them more readily than the crops they are about to attack, discontinue their depredations and turn their attention to the poisoned material.

In one sense the planting of trap crops belongs in this group of treatments; in another sense it should be classed with the preventives. Very frequently when some particularly early-maturing varieties of a crop are grown, the pests turn their attention to them while the later varieties are coming on. As a result, this concentrated attack may seriously injure these earlier fields where if the attack were spread out over the larger extent of ordinary varieties it would not be so noticeable. If the earlier varieties alone were grown the result would be the same as if all were grown later, so far as diffusion of attack is concerned, unless the species of pest habitually disappears before the regular crop comes on and this crop, then, escapes by reason of its later maturity. However, this circumstance is frequently made of use and where the normally maturing crops are grown, it is possible to trap the plant enemies by setting out a small plot early. The pests are thus concentrated on this small area which may then be entirely destroyed along with the pests before the time when the harvest crop would be subject to attack.

There are probably few insects which do not have one or more natural enemies, and this explains why the majority of insect forms never make their presence felt by the severity of their depredations because their natural enemies keep them so well under control. This is a fortunate fact. Insects are sometimes exceedingly prolific. The female "anay" has been known to lay eggs at the rate of one per second, sixty to the minute, which gives a possibility of eighty-six thousand four hundred per day, since the queen lays continously when once she begins.

Another striking illustration is found in the plant lice or aphids. Under certain conditions these produce young alive, each one of which may, when grown, give birth to others without any fertilization or oviposition being necessary. The rate of production may be 8 per day, not high when compared with the "anay," but in five days the adult stage may be reached and each of the 8 produce 8 more. Taking this as continuous, as it may easily be, and supposing that no natural checks operate to destroy any of the insects, supposing even that each louse produces only 8 others (one day's production), at the end of two months the number of aphids descended from a single stem-mother will be over seventy-eight billion, five hundred million, enough, allowing each insect two millimeters of length, if placed "head to tail," to cover a distance of over seventy-eight thousand, five hundred kilometers. When it is considered that the reproduction of each adult louse is not confined to one day but goes on for a number of days, the possibilities thus opened are startling.

This enormous rate of increase is necessary to these soft-bodied insects as they are not capable of much self defense and their enemies would otherwise quickly annihilate them. As it is, some of them never become serious pests and this is also true with many other species which do not increase so rapidly.

Many sporadic outbreaks are caused by a sudden decrease in the number of parasites and predators which prey on the pest in question. Usually this increase produces such an abundance of food for the parasites and predators that they, too, are soon able to increase accordingly and again regain the upper hand.

When, however, man introduces some plant pest into a new region without its accompanying enemies, the pest may soon increase beyond the bounds of safety and the farmer suffer in consequence. It has been possible in some instances to introduce the natural enemies of the pest and so bring the latter under control, but this does not always work out in actual practice. When man destroys the insectivorous birds, even though they may be doing a small amount of damage to his crop, he is reducing the number of allies which can do far more than he to keep down more serious plagues. Often in cultivating ground, man destroys unconsciously the retreats of predaceous foes to crop pests, but as this cannot be well helped it must be counteracted by more assiduous work in other directions. Fortunately some pests are also destroyed by the same operation. Absolute bird protection, until it is actually proven that certain birds are more injurious than beneficial, is one of the best insecticidal methods that can be followed.

Some parasites prey upon other parasites, which in turn attack still others and these yet more, the primary parasites perhaps attacking the foe of some plant while the tertiary or quaternary parasite is in turn preyed upon by some predaceous enemy which may be itself parasitized. This question of parasitism and hyperparasitism has long been studied and is of exceptional interest. It has a practical value in more ways than one. The agriculturist should bear in mind that the fact that certain insects are noted to be exceedingly abundant in a certain field should not be taken as conclusive proof that those insects are the cause of any damage to the plants. They may be the controlling factor with respect to the real pest.

Practically speaking, too much reliance should not be placed in the idea of controlling widespread pests by means of introduced parasites. It is true that in some cases this has worked out satisfactorily, and it is also true that it can be made to work in other instances, but when the prevalence of a pest is due to the change of conditions which man has brought about, absolute relief may be sought only in the reëstablishment of the balance of nature which in its theoretically perfect condition keeps all forms of life from undue increase and within normal bounds although it does not totally destroy any entire group. Sometimes the normal bounds are not the bounds of neutrality or else normal conditions are undesirable and recourse must accordingly be sought in measures operated by man himself.

Preventive measures may be taken to mean the dust sprays, the smudges, the insect powders such as pyrethrum, and the various types of "scare-crows" that are often used and which tend by their presence to direct the attack of the pests to other situations not thus protected. They include the ditches dug around fields to keep swarming caterpillars and grasshoppers from entering, the tarred bands around tree trunks to keep certain insects from ascending to the foliage, the pans of water by means of which furniture is protected from the ingress of ants, the whitewashes and sacking placed on trees to keep the borers from getting to the bark, and the screens and mosquito bars on houses and beds to keep out flies and mosquitoes. They may also be considered as including the various forms of farm practice which tend to make the attacks of the pests less effective, such as the fertilizing of weak soils, the cultivation of resistent stocks and the general cultural methods which neutralize insect attack and some of which also cause a certain amount of mortality among the plagues as do early or late planting, seasonal plowing, and the like.

Perhaps the most important measures, at least to the agriculturist, are the practice of clean culture, the betterment of agricultural methods, and the improvement of crops. Insects of many kinds love rubbish. They breed in such places in countless numbers, they hibernate in them, they live in them. When such places are kept cleaned up and weed patches are given attention regularly, it will be found that the number of insects present in the fields decreases materially. Some forms of pests may be entirely controlled in this manner if the work is thoroughly done. Certain crops, when it is not possible to destroy the insects present upon them, may be developed to such a healthy, hardy condition that the attacks of the pests do not reduce the vitality of the plants below a point where the harvest may still be profitable. If the insects are capable of being destroyed the advantage is of course all the more marked. It should be remembered that the hardier a plant is, the better can it withstand pest attack, permit severe remedial measures to be performed on it if necessary or the better can it recover from damage which may be inflicted upon it. Therefore, if practices are followed which bear out these principles, the work of pest extermination by artificial means, when it becomes necessary, is materially reduced and the effect of such work increased.

HYBRIDIZATION OF ANNONAS.

By P. J. WESTER, *Horticulturist in Charge of Lamao Experiment Station.*

Experiments in Annona hybridization were begun by the writer in 1908 at the Subtropical Garden, Miami, Florida, and continued during 1909 and 1910, an account of which was published in the Bulletin of the Torrey Botanical Club, Vol. 37 (1910), pp. 529–539. When the writer accepted his present position he brought with him to the Philippines in 1911 a few seeds, the result of a cross between the sugarapple (*Annona squamosa*), the mother plant, and the cherimoya (*A. cherimolia*), from which 24 plants were raised and planted out at the Lamao experiment station. One of these hybrids, No. 4, ripened one fruit in 1913, which was described in THE PHILIPPINE AGRICULTURAL REVIEW, Volume VII (1914), No. 2, page 70, and the hybrids were named atemoyas to distinguish them from other annonaceous fruits. In 1914, nineteen more hybrids bore from 1 to 46 fruits each, or 203 fruits in all.

As the plants came into bloom quite a number of crosses were made between the atemoya seedlings and other annonas, as follows: three between the sugarapple and the atemoya, sixteen between the custardapple and the atemoya, ten between the "Giant" cherimoya from Australia and the atemoya, and 23 between the mamon (*Annona glabra*) and the atemoya. In practically all cases fruits of greater or less size resulted. It is perhaps worthy of note that in every instance where mamon pollen was employed the pulp was lumpy and the quality of the fruit was defective. The seeds in these fruits were also very largely defective, and of those that appeared to be fertile and were planted not one has germinated.

In order to insure the setting of a large number of fruits on the hybrid seedlings many flowers were hand pollinated, and most of the fruits were unquestionably produced thereby. The resultant fruits are consequently no indication of the productivity of the trees under ordinary conditions. Pollinating *Coleoptera* were present in very small numbers on the atemoyas as com-

pared with the custardapple and sugarapple. The pollinations were begun March 20, 1914, and concluded April 8; the earliest fruit ripened June 30, and the last was picked August 1. Nearly all matured during the rainy period.

The atemoya plants (Plate V, *b*), of which there are 24, all grown from seed from one fruit, greatly surpass the parents in vigor, and are very similar in habit, stems, leaves and flowers to the cherimoya. In fact the only trace of the mother parent is found in the absence of the velvety under surface of the leaves which characterizes the cherimoya. With respect to the parent variety of cherimoya the leaves of the progeny are frequently twice as large as in those of the parent, and they have inherited the elongated shape of the leaf of the sugarapple (Plate X, *a*, *b*, *d*) being 16 to 22 centimeters long and 8 to 12 centimeters broad. The flowers are indistinguishable from those of the cherimoya (Plate IX, *a*,), and like that species the atemoya sheds the pollen in the afternoon.

Exteriorally the fruits have exhibited greater variation than any other part of the plant; No. 4, which fruited in 1913 and was described in the Review last year, most closely approached the cherimoya in quality. In the fruits of those seedlings that fruited in 1914, the cherimoya flavor was more or less apparent in six hybrids, the rest not having any distinctive cherimoya flavor; in quality, no one was inferior to, and a number were distinct improvements upon, the sugarapple.

Fruits weighing less than 100 grams have been considered as culls and have not been included in making the descriptions or in computing the average weight of the fruit of a hybrid. Generally speaking, the small size of the fruits has been a disappointment, though it should be recorded that the parent cherimoya was not much larger than an ordinary sugarapple. (Plate VI.) It is perhaps also worthy of notice that some of the fruits on one plant were more than twice as large as either parent (Plates VI, *c*, VII, *d*). In this connection it may be said that the average sugarapple weighs 200 to 250 grams. An annonaceous fruit of this weight is of about the right size for a dessert fruit of this kind served singly. Large annonaceous fruits are preferable to smaller ones principally because the seeds then become less objectionable than in a smaller fruit; the flavor and quality in a large fruit are also somewhat enhanced. All descriptions are made from fruits ripening in 1914.

The following is a description of the fruits:

No. 2. Weight 150 to 225 grams; length 70 to 72 millimeters; width 60 to 75 millimeters; shape cordiform; areoles distinct; carpels more or

less prominent, ending mostly in an acute dark-green, corrugate point; carpellar surface green with white bloom, area along areolar lines cream colored; skin medium thick, rather brittle; pulp white, juicy, melting and sweet, with trace of acid, and pronounced aroma and flavor of cherimoya.

No. 2 yielded three fruits of which two were produced through a cross with the mamon, and one by a cross with the sugarapple. The description of the flesh is made from this latter fruit, the flesh of the other two being more or less defective.

No. 3. Size very small, 100 to 145 grams in weight; length 58 millimeters; width 55 millimeters; shape more or less irregularly cordiform; carpels equal, to more or less raised, light green, frequently dark green and corrugate at stigmatic point; areoles distinct; skin variable in thickness and toughness; bloom white; pulp white, juicy, sweet, almost watery, faintly aromatic, devoid of cherimoya flavor; quality good, about equal to a good sugarapple.

This tree bore 12 fruits of which only 2 weighed above 100 grams, and the small size and the lack of distinct qualities eliminates it as a desirable fruit.

No. 5. (Plate VIII, *b*.) Weight 130 to 235 grams; length 54 to 65 millimeters; transverse diameter 58 to 72 millimeters; shape regularly cordiform, sometimes broader than long; carpels a trifle depressed, equal to slightly raised towards base; areoles distinct; surface smooth, greenish with red dots on sun-exposed side; bloom white; skin medium thick and fairly tough; flesh white, juicy, without objectionable fiber, sweet, with a trace of acidity and a suggestion of cherimoya flavor.

Of thirteen fruits on this plant nine weighed above 100 grams. In attractive appearance they surpassed all fruits on the sister hybrids, and were markedly superior in quality to the sugarapple.

No. 6. Weight 115 to 250 grams; length 57 to 84 millimeters; diameter 52 to 75 millimeters; shape cordiform; carpels usually depressed or equal on apical half and raised towards base; areoles distinct; surface greenish with white bloom; skin quite thick and tough; pulp white, with scarcely noticeable fiber, juicy, sweet, of good flavor, with little or no trace of the cherimoya flavor, faintly aromatic.

Fourteen fruits out of twenty-seven weighed more than 100 grams, of which three exceeded 200 grams. In quality No. 6 compares favorably with a good sugarapple.

No. 7. Weight 145 to 190 grams; length 60 to 65 millimeters; transverse diameter 60 to 63 millimeters; shape regularly cordiform; carpels equal to a trifle raised; areoles distinct; skin thin, but quite tough; pulp white, with weak, unobjectionable fiber, sweet, juicy, faintly aromatic, cherimoya flavor absent.

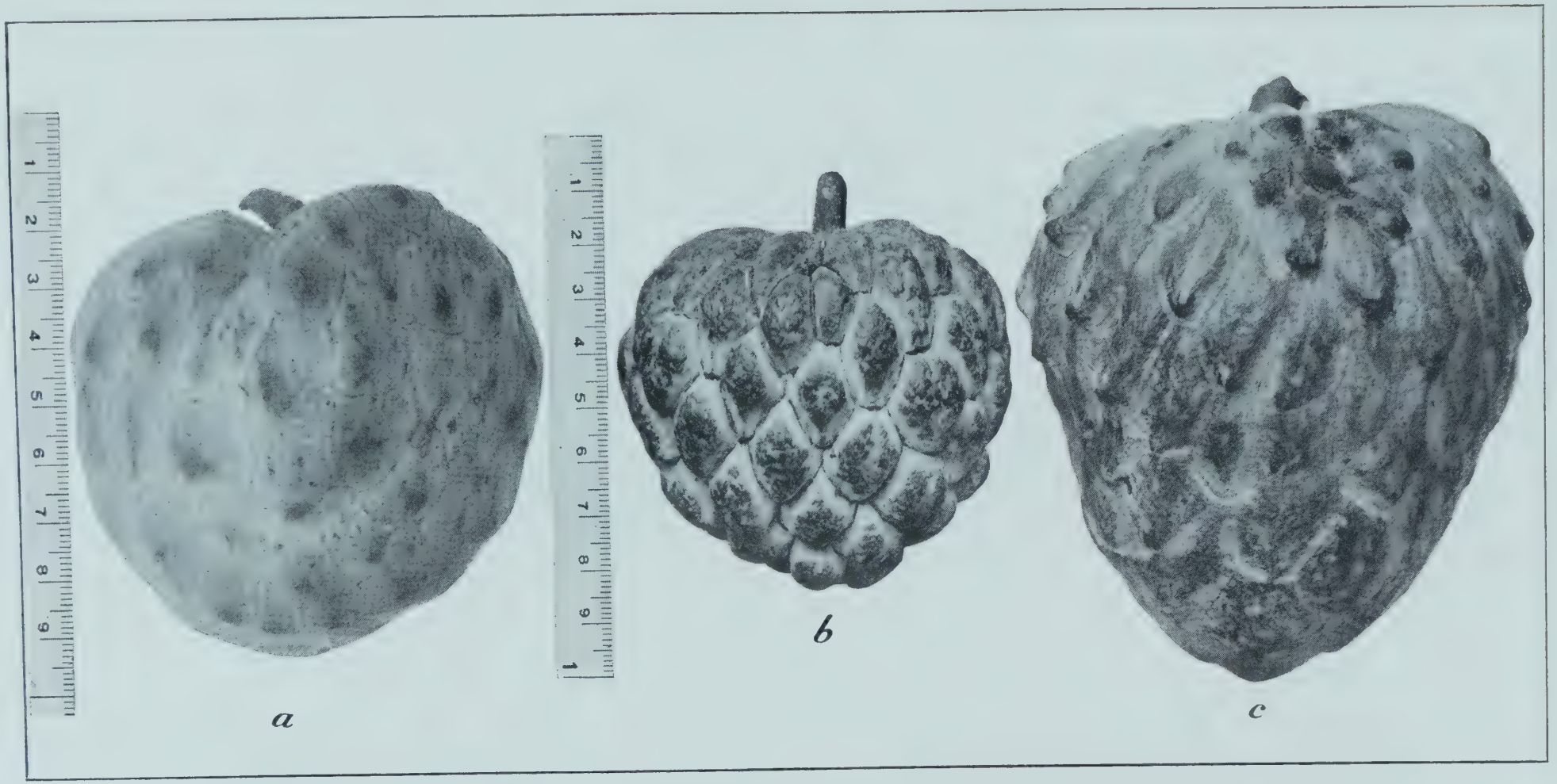
This tree carried three fruits of which two weighed above 100 grams; about equal to or a little better in quality than the sugarapple.



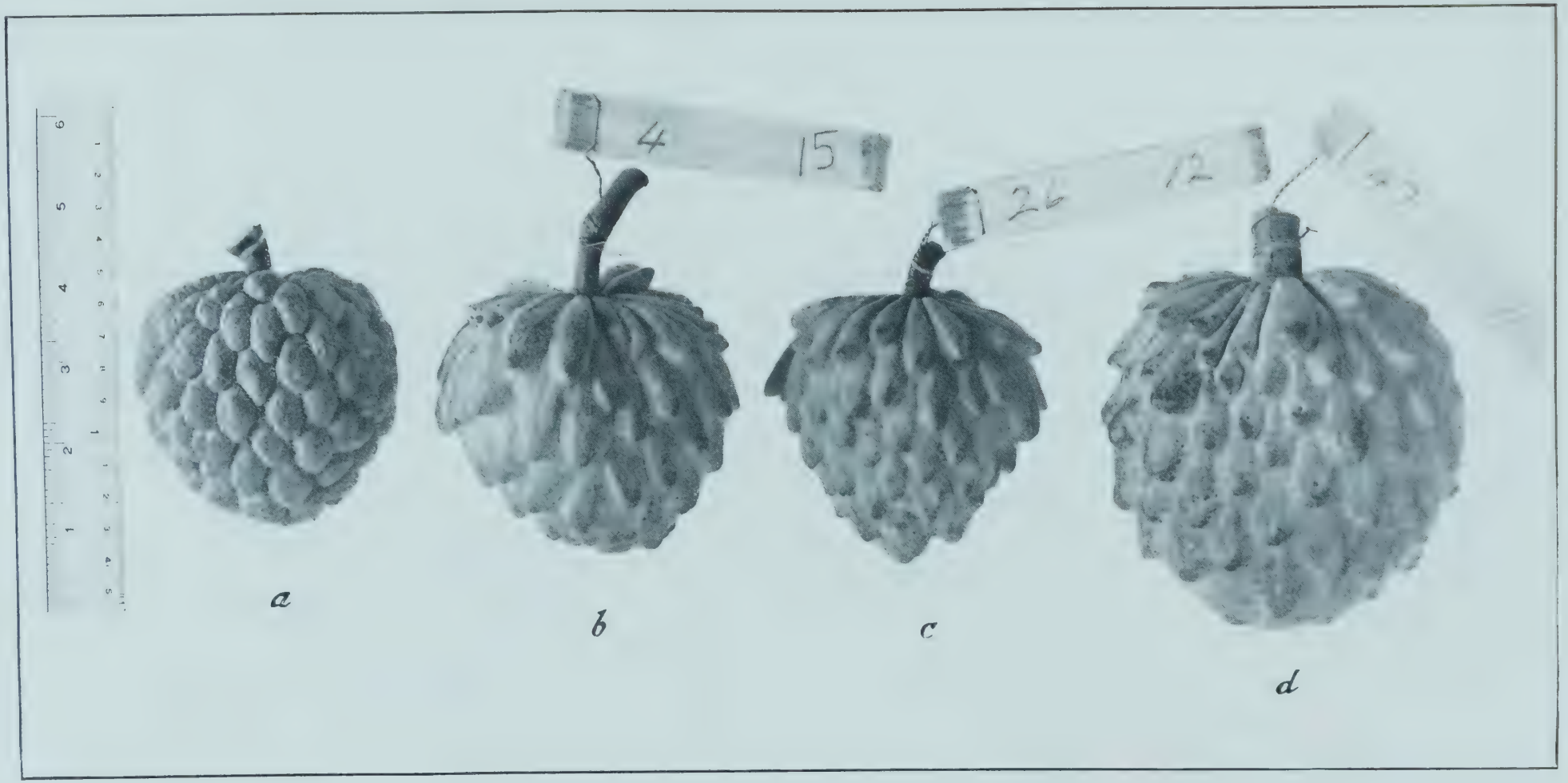
(*a*) A bunch of fruit of the lipoti, *Eugenia curranii* C. B. R.



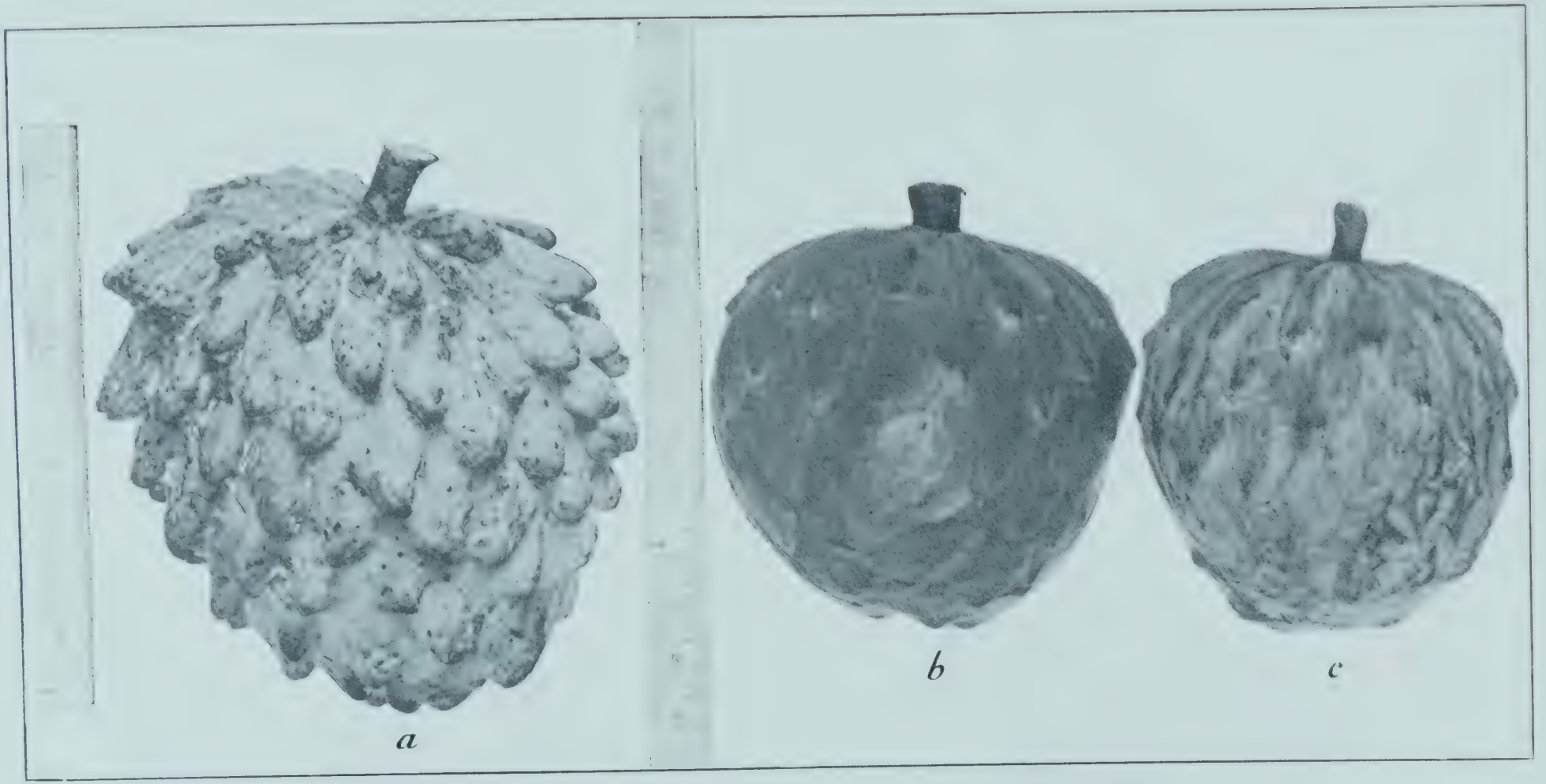
(*b*) Atemoya tree in fruit; age of tree three years. Lamao Experiment Station. 1914.



(*a*) Cherimoya, staminate parent. (*b*) Sugarapple, pistillate parent. (*c*) Atemoya, hybrid between sugarapple and cherimoya.



(*a*) Sugarapple. (*b*) (*c*) (*d*) Atemoyas with prominent carpels.



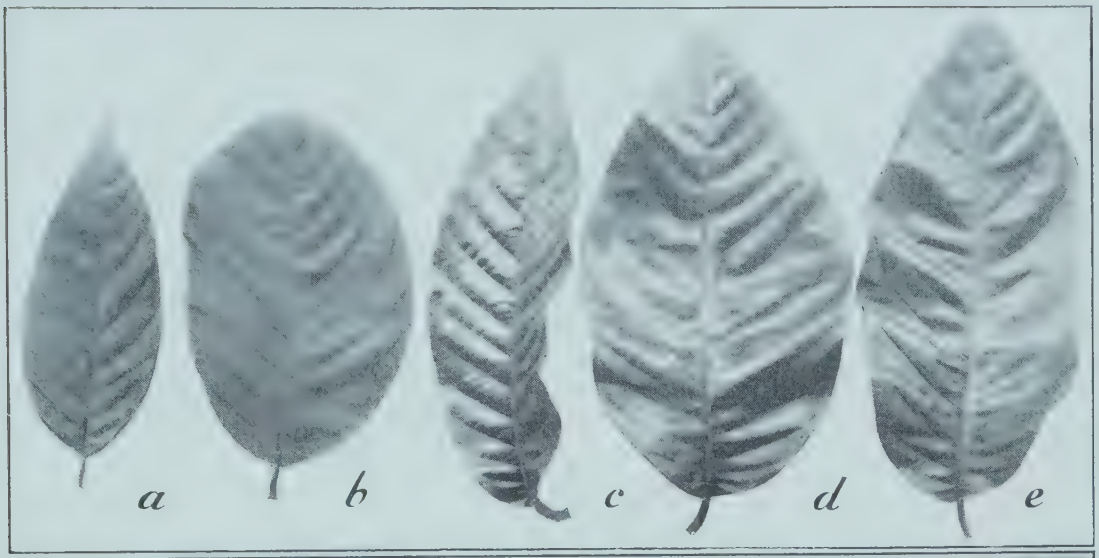
(*a*) Atemoya with prominent carpels. (*b*) and (*c*) Atemoyas with carpels not prominent.



(a) Flowering branch of the atemoya (the flowers are identical with those of the cherimoya).



(b) Flowering branch of the sugaraticle.





(*a*) Leaf of sugarapple, *Annona squamosa*. (*b*) Leaf of cherimoya, *A. cherimolia*. (*c*) Leaf of custardapple, *A. reticulata*. (*d*) Leaf of atemoya, hybrid between sugarapple and cherimoya. (*e*) Leaf of cuatemoya, hybrid between atemoya and custardapple. (*f*) Flowering branch of the cuatemoya.

No. 8. Size very small, weight 105 grams; length 56 millimeters; width 50 millimeters; shape irregularly cordiform; carpels prominent, ending in a more or less acute point; areoles distinct; surface pale greenish, mottled with reddish purple dots on sun-exposed side along areolar lines; skin thin to medium thick, brittle; pulp white, very juicy, almost watery, sweet, with a trace of acidity and cherimoya flavor.

Only one of three fruits weighed more than 100 grams. In quality the fruit is a slight improvement on the sugarapple.

No. 9. Size very small, weight 135 grams; length 55 millimeters; transverse diameter 60 millimeters; shape regularly cordiform; carpels equal or a trifle raised; areoles distinct; bloom white; pulp white, juicy, sweet and aromatic, rich, flavor suggestive of cherimoya.

The tree bore one fruit only, quite superior to the sugarapple in quality.

No. 11. (Plates VI, *c*, VII, *d*, VIII, *c*.) Size small to medium; average weight 220 grams; length 74 millimeters; equatorial diameter 62 millimeters; shape cordiform, usually longer than broad, regular; carpels variable, sometimes depressed, usually equal and occasionally quite prominent; areoles distinct; surface greenish with white bloom; skin medium thick of average tenacity; flesh white, juicy, sweet, faintly aromatic, of good flavor, cherimoya flavor absent.

No. 11 bore forty-seven fruits of which twenty-nine weighed over 100 grams with a greater average size than any of the seedlings, one fruit weighing 580 grams. The fruit slightly surpasses the sugarapple in quality.

No. 12. (Plates VII, *c*, VIII, *a*.) Size small; weight from 135 to 255 grams, with an average of 175 grams; length 65 millimeters; transverse diameter 60 millimeters; shape cordiform, regular; carpels ending in a more or less pointed protuberance; areoles distinct; surface green with reddish dots on sun-exposed side; bloom white; skin quite thick and tough; pulp white, juicy, sweet, faintly aromatic, devoid of cherimoya flavor, but of good quality.

Thirteen of the twenty-six fruits of this plant weighed above 100 grams. It is one of the two most attractively colored hybrids. In flavor it slightly excels the sugarapple.

No. 13. One hundred and sixty-five grams in weight; 65 millimeters in diameter; shape cordiform; carpels more or less prominent; areoles distinct; bloom white; skin thin, brittle; pulp white, sweet, juicy, with a trace of cherimoya flavor.

Four fruits were produced on this tree, superior to the sugarapple in quality.

No. 14. Weight 110 to 175 grams; diameter 60 millimeters; shape cordiform, regular; carpels equal or a trifle raised, ending in a protuberance at stigmatic point; areoles large and distinct; surface pale green, granulate; bloom white; skin medium thick, of average tenacity; pulp white, juicy, sweet, with a little or no cherimoya flavor, but of very good quality.

Three of a total of nine fruits reached a development of above 100 grams. The larger areoles and granulate surface in this fruit distinguish it from all the sister hybrids. It is superior to the sugarapple.

No 15. (Plate VII, *b*.) Weight 100 to 185 grams; length 55 to 63 millimeters; width 53 to 72 millimeters; shape cordiform; carpels very prominent, protuberances dark green and somewhat corrugate, depressed areas yellowish; bloom white; pulp white, juicy, sweet, faintly aromatic, of little or no trace of cherimoya flavor, surpassing somewhat the sugarapple in quality.

This plant bore six fruits of which two weighed 100 or more grams. Remarkable chiefly for its large carpels.

No. 16. One hundred to 155 grams in weight; 53 to 66 millimeters in diameter; shape cordiform, regular; carpels more or less prominent, ending in a pointed, corrugate, dark-green protuberance, sometimes 4 to 5 millimeters long; surface yellowish along areolar lines; bloom white, skin medium thick, quite tough; pulp white, sweet, juicy, faintly aromatic, of good flavor, but devoid of cherimoya flavor.

Of twelve fruits six weighed 100 grams or more. The fruit partakes more of the sugarapple than of the cherimoya in appearance; in quality it excels the sugarapple.

No. 17. Weight 130 grams; diameter 52 millimeters; shape cordiform; carpels prominent, dark-green and corrugate at apex; areoles distinct; bloom white; skin thin and rather brittle; pulp white, juicy, sweet, rich, faintly aromatic, with trace of cherimoya flavor, of good quality.

One only of ten fruits borne by this tree that were tested weighed more than 100 grams. Three attractive fruits of good size dropped from being overripe before they were picked.

No. 22. Weight 115 to 200 grams; length 60 to 63 millimeters; width 59 to 66 millimeters; shape cordiform; carpels equal or slightly raised; areoles distinct; bloom white; skin thin but rather tough; pulp white, a trifle fibrous, juicy, sweet, quite aromatic, well-flavored.

Four of six fruits weighed more than 100 grams. Superior in quality to the sugarapple.

No. 23 bore two undersized prominent-carpelled fruits of good flavor.

The fruits of Nos. 1, 18 and 19 became overripe on the trees and were lost.

It should be remembered that most if not all of the fruits described above were produced by artificial pollination, and since the value of a variety greatly depends upon its productivity, the value of these hybrids to the public is by no means determined, and this cannot be done until after at least three crops of fruits have been recorded.

During 1915 the hybridization work was continued and seventeen successful crosses were made between various atemoya mother plants and the "Giant" cherimoya from Australia, referred to in a previous issue of the Review; twenty crosses were made between the atemoya and the soursop, *A. muricata,* the latter supplying the pollen, four of which resulted in small deformed fruits with few seeds. Eight successful crosses were made between the sugarapple, mother, and the custardapple, *A. reticulata,* which, by the way, was first accomplished in 1908 in Miami, Florida, though the resultant hybrids were lost during the absence of the writer. Ten crosses were made between the sugarapple and the "Giant" cherimoya. Several crosses were also made between the soursop and sugarapple, the soursop and custardapple, the biriba and sugarapple, and the biriba and custardapple, all of which were abortive.

The hybridization was begun April 4 and concluded April 17, and all the fruits on the atemoyas matured before the advent of the rainy period.

The atemoya plants have continued to make excellent growth. They flowered normally in 1915 with abundant blooms. and a fair number of small *Coleoptera* of the family Nitidulidæ being present, a fair crop of fruit was anticipated. It is therefore disappointing to record that very few fruits set where the flowers were not handpollinated. Those that ripened had the distinct flavor and aroma of the cherimoya, and were greatly superior to the fruits from the same trees in 1914, which, it is recalled, matured during the rainy season. It is hoped that as the hybrids grow older they will become more productive.

As will be noted in reading this paper the work has been disappointing so far in several respects and, commercially speaking, no hybrid has yet been produced that is a success. The permanent value of the work lies in the demonstration of the possibility of hybridizing the species under consideration and more particularly in the demonstration of the fact that it is possible to combine in the progeny more or less of the quality of the subtropical cherimoya with adaptability to tropical conditions.

A large number of hybrids from the seeds secured in 1913 and 1914 are now growing and some of the hybrids between atemoya No. 4, and a custardapple, bloomed in 1915 when the plants were about eighteen months old. (Plate X, *e, f.*)

PLANTATION WHITE-SUGAR MANUFACTURE.

By CLEVE. W. HINES, M. S., *Station Superintendent.*

The demand for high-grade sugar has become so great that men in every sugar-producing country are seriously considering the advisability of arranging their factories for the production of high-grade sugars directly from the cane juice in one continuous process.

It was the universal custom until quite recently to make a low-grade or crude sugar in the plantation factory and this was afterwards sent to a refinery and converted into a high-grade sugar by the aid of the bone-black or animal-char process. This procedure entailed the expense of transporting the raw sugar to the refinery, costly refining expenses, and again the return transportation on the finished product. In addition to all of these expenses there is a loss of sugar incident to the handling during transportation and refining which would be eliminated were the high-grade sugar made at the plantation factory.

It was formerly believed that the bone-char method was the only one which would produce a first-class sugar but in recent years there have been elaborated numerous systems of clarification and filtration which give a very satisfactory sugar in one continuous process. Sugars are thus produced which have practically as high a purity and as bright a color as those made by the bone-black process.

The sugar manufacturer using cane as his source of sucrose is favored with the advantage that the small amount of impurities which may be left in his product will lend to it a very pleasant flavor. If indeed it were possible to make his sugar perfectly white and have a sharp brilliant crystal, such as is universally demanded by consumers, without removing all of the organic impurities, the sugar would have a distinctive flavor and odor making it far superior to the sugars of a higher purity. It was this quality in the famous Demerara crystals which caused their superiority over other yellow clarified sugars. It should be noted in this connection, however, that only the natural impurities found in mature cane lend these pleasing flavors while those

which are found in deteriorated or damaged cane are of a much lower quality.

When high-grade sugars are made directly from the cane, the expense of manufacture is ordinarily very much lower, since the same skilled workmen as well as the evaporators and other expensive apparatus required for the manufacture of lower-grade sugars will be used. In addition, the bagasse from the cane and occasionally the low-grade discard molasses, two by-products of the plantation factory, will provide the only fuel needed, an otherwise very costly item in the refinery. The first process in the refinery is to melt the crystals, and dilute the solution to a low density, then after the clarification and filtration the sugar is recrystalized. This requires a great deal of extra heat and the attention of specially trained men. The bone-char used in refining is very expensive and while it is customary to use this clarifying and filtering agent over and over again, nevertheless there is a considerable loss during each operation and the cost of reviving or reburning it is quite appreciable.

In some of the Oriental countries, including Java, there has been a demand by the inhabitants, particularly by the Hindus of India, for sugars made without the use of bone-black, since there is a prejudice against the use of any article in the manufacture of which animal substances are used. A search was then made for new methods of clarifying and filtering juices whereby the high-grade sugars could be produced without the use of bone-black.

The beet-sugar manufacturers also conceived the idea of eliminating the refining expenses and elaborated systems of clarification which produced sugars answering quite favorably to the standards of the refinery. This gave rise to the system now used generally throughout the beet-sugar factories which consists of a double carbonation and sulphitation method with careful attention given to filtration. The method as used for beet juices could not very well be employed with cane juices, which contain a high percentage of glucose, since dark products would result from the compound of calcium used in the clarification and glucose and these products are very detrimental to the manufacture of high-grade sugars.

Among the systems enumerated later, there is mentioned one which produces a juice practically as free from glucose as the beet juice. With the glucose eliminated there is no danger of the juice darkening when heated to a high temperature even though it be in an alkaline state. Special treatment and great care, however, are necessary in order to produce such a juice.

The first essential in the manufacture of white sugar directly from the cane juice is to properly strain or filter the juice as it leaves the mills in order to remove as much of the foreign substances as possible and particularly cane fiber. The particles of cane fiber or bagasse thus removed contain coloring substances, which would become quite yellow in an alkaline medium, while the outer tissue contains a great deal of the coloring substance, "anthocyan," which is extremely soluble and is quite noticeable, especially when the darker varieties of cane are used. These are partly soluble in the juice and render the subsequent work more difficult if they are present in large quantities.

The clarification of the juice which is to produce a high-grade sugar should be given the most careful attention. It is essential that the entire process be under the strictest chemical supervision and that only qualified workmen be intrusted with the operations. Errors made at this stage are very difficult or almost impossible to correct later.

Lime is one of the principal agents used in this work. It first neutralizes any acids that may be present, both organic and inorganic. It also acts upon albuminous substances and other organic compounds. These pass to the bottom of the defecators and act to a certain extent as a mechanical precipitant by bringing down other suspended impurities. Only the best quality of burned lime should be used since impurities introduced into the juice with the lime may cause a great deal of future trouble, especially if they consist of such elements as magnesium and potassium which are often present in low-grade lime rock. The lime used for juice clarification results from the burning of lime rock or calcium carbonate. The chemical change which takes place during this process or burning is expressed in the following equation: $CaCO_3$ (calcium carbonate) presence of high temperature $\rightarrow CaO$ (calcium oxide) $+ CO_2$ (carbon dioxide). This calcium oxide is very alkaline and decomposes water during which calcium hydroxide is formed. With this operation, known as slaking of the lime, there is a great deal of heat evolved. On account of this heat and the strong alkalinity produced locally it is usually considered a poor practice to apply lime to cane juices in the oxide or unslaked form. The following equation indicates the reaction which takes place when unslaked lime combines with water: CaO (calcium oxide $+ H_2O$ (water) $\rightarrow Ca(OH)_2$ (calcium hydroxide). Having selected a first-class lime for the clarification work the next question of importance is the proper preparation of it and the addition to the juice of the proper quantity. This will depend upon the particular process employed.

In practically all of the methods now used for making plantation white granulated sugar sulphur dioxide is employed as an acidifying and bleaching agent. This is sometimes applied before the lime so that the acidity of the juice will be increased, thus admiting the use of more lime. In other methods the lime is added first and the sulphur dioxide afterwards. In addition to the above-named action sulphur dioxide serves still other purposes, especially when used in connection with the carbonitation system. There is present in cane juices a certain quantity, though it may be small, of potassium. When this is acted upon by the carbon dioxide, potassium carbonate results. During the boiling of the juice this potassium carbonate is decomposed and the potassium compounds thus liberated have very strong alkaline effects and immediately act upon the glucose present, forming dark-colored products. If the juices are previously subjected to the sulphur treatment, however, this compound would be changed into potassium sulphate which is quite insoluble and the trouble thus eliminated.

Sulphur dioxide gas is usually made in the factory as needed by burning crude sulphur in a properly constructed furnace and conducting the gas through pipes to the juice after it has been thoroughly cooled. The reaction which takes place in the burning of sulphur is as follows: S (sulphur) + O (oxygen) presence of high temperature $\rightarrow SO_2$ (sulphur dioxide).

When this gas is absorbed by water in the cold the following formula results: SO_2 (sulphur dioxide) + H_2O (water) $\rightarrow H_2SO_3$ (sulphurous acid). This is a fairly weak acid and is the compound sought for in sugar manufacture. It is formed, however, only when the combination is made at fairly low temperatures while if this should take place with elevated temperatures, the following formula would result: SO_2 (sulphur dioxide) + H_2O (water) + O (oxygen) presence of high temperature $\rightarrow H_2O_4$ (sulphuric acid). This acid is extremely powerful and will not only destroy sucrose, but will corrode the iron containers of the juice as well. For this reason care should be exercised that the gasses are properly cooled before coming into contact with moisture.

It is very important that the sulphur be properly burned so that a gas with as high a percentage of the sulphur dioxide as possible be attained. The theoretical amount attainable is about 21 per cent. Usually, however, a gas with not more than 17 to 18 per cent is received in practice.

Carbon dioxide gas is also extensively used with many of the processes. This gas is recovered as a by-product from the burning of limestone and is used for the precipitation of the

calcium and impurities in juice clarification. The following formula expresses the reaction which takes place when the gas combines with calcium hydroxide: $Ca(OH)_2$(calcium hydroxide) $+ CO_2$(carbon dioxide) $\rightarrow CaCO_3$(calcium carbonate $+ H_2O$-(water). This calcium carbonate is quite insoluble and acts as a mechanical precipitant in addition to the chemical effect of the two components.

Proper temperature regulations during clarification form a very important factor, which must not be neglected, and it is only with close attention to such details that good results may be attained.

The next operation is the proper subsidation of the juice whereby the heavy impurities will settle to the bottom while the clear juice remains at the top and is decanted or drawn off. This procedure eliminates the filtering of the entire quantity of the juice which contains so many impurities that it would be a very difficult task since the impurities form a gelatinous coating over the cloths of the filter presses thus preventing the penetration of the juice. Since the impurities settle out of the clarified juice very completely, if the work has been properly done, there is usually little to be gained by filtering the clear supernatant liquor.

The handling of the juice after this stage will be determined by the particular process employed, the condition of the original juice and the grade of the finished product required. When it is desired to make the highest grade of refined sugar special attention must be given to proper juice clarification and subsidation. In some cases a second application of the above reagents may be necessary while in others such additional reagents as "blankit" or sodium hydrosulphite. Phosphoric acid, sodium or calcium phosphate, etc., may be employed to advantage after the first concentration or syrup stage is reached. It is sometimes desirable to treat the concentrated product and thus remove still more impurities, but this is not ordinarily necessary when the work has been properly done in the previous operations. The following brief description of various processes will serve to indicate the general principles involved in each.

Harloff's acid thin-juice process.—This is a carbonitation-sulphitation process, the main features of which are based on the principle that there is present in all carbonated juices calcium carbonate and bicarbonate, calcium sulphate and some potassium in the form of a carbonate. Upon decomposition of the latter during the concentration of the juice a dark color will be taken on by the thick liquor unless its chemical composition is previously changed. Calcium sulphate being more

stable will not be so susceptible to this change and consequently the thin juice is made distinctly acid with sulphur dioxide before concentration is begun, which has the additional effect of clarifying and bleaching the juice.

Battelle process.—This method was patented by Mr. E. E. Battelle of Hawaii and aims at producing a juice for concentration which is very similar to clarified beet juice. His first step is to remove the glucose content of the juice which is accomplished by heavily liming and heating the juice to a high temperature. The juice is then treated with carbon dioxide, filtered, retreated with lime and carbon dioxide, and, if found necessary, again filtered, bleached with sulphur dioxide or treated with phosphoric acid and concentrated. The molasses is passed through a cold saccharate process somewhat similar to the Steffens process whereby the greater percentage of the sucrose is removed.

The Reserve or Sandmann system.—This system was elaborated by Mr. B. Sandmann after many years of application to the subject of plantation white-sugar manufacture at the Reserve sugar factory of Louisiana.

Briefly stated, the system consists of heavily sulphuring the raw juice and liming it down to an acidity of about 1.2 cubic centimeters against 1/10 sodium hydroxide, using Phenolphthalein as an indicator. The juice is then heated to the desired temperature and placed in subsiders for a time after which the clear juice is drawn off. The portion of the juice containing the sediment is then filtered through presses. Before boiling the clarified juice is treated with a special sodium-phosphate paste which has an acidity practically equal to that of the clarified juice. This has the effect of decreasing the amount of calcium remaining in the juice, thus giving a solution which will be more easily boiled and will work better in the machines. By this treatment there is more of the sulphite removed, a part of which would otherwise be admitted into the sugar together with a trace of glucose and other reducing compounds which would later transfer it into sulphide and thus cause the sugar to darken.

Java process.—This method varies somewhat with the different factories but consists in general of single or double carbonitation, subsidation, filtration and bleaching with sulphur dioxide, particular attention being given to the control of temperatures, alkalinities or acidities of juices and sirups.

Adeline or Oxnard process.—The essential features of this process consist of heavily sulphuring the juice to admit of more lime being used, and reducing the acidity to about one cubic

centimeters against N/10 sodium hydroxide, using phenolphthalein as an indicator. The juice is then subsided, treated with phosphoric acid, and again limed if necessary. It is then filtered and concentrated.

The thick juice is still further treated with phosphoric acid or sulphur dioxide if necessary.

Dehann process.—This is a carbonation system designed to minimize the amount of lime used for the clarification of the juice by causing the calcium carbonate to be crystallized in a firmer and more granular form which is more readily removed by subsidation and filtration.

Bach process.—It is observed that corrosion of the evaporators and loss of sucrose through inversion result when the juices are carried in an acid condition during concentration. For this reason the Bach system was devised by which the sulphur dioxide treatment of acidifying the juice is given after the syrup stage is formed; until this time the juice is kept neutral.

Weinrich process.—The one unique feature of this process consists in the application of dry lime to the raw juice instead of the slaked or hydrated form as is universally employed. It is interesting to note in this connection that sugar manufacturers have always been very much averse to the application of lime to cane juice except in the hydrated form, assuming that such treatment would be extremely dangerous to the color of the juice because of the reducing sugars present, since there would be local heating of the juice from the heat evolved by the chemical action during the slaking of the lime. There is also likely to be a high alkalinity thus formed in the portions of juice which come into direct contact with the calcium oxide.

Roselle process.—This system consists of first thoroughly removing the "bagasillia" from the juice, sulphuring heavily, liming and subsiding. Phosphoric acid is then applied, when required, and the resultant precipitate carefully filtrated.

Wijnberg and Spaner process.—This is a patented system consisting of the application of decolorizing carbons to the limed and sulphured juice, and the application of a limited quantity of "Kieselgvhr," after which the juice is filtered. The decolorizing carbons are removed with the filtrate and revivified by treatments with caustic alkali and washing.

Weise process.—This is a carbonitation process in which two or three per cent of lime is added to the raw juice before the gas is applied. Subsequent work consists of subsidation, filtration and bleaching.

Steffens process.—This process was the result of a great deal of experimenting and was improved step by step starting with what was known as the "elution process."

It deals with the principle that calcium combines with sucrose to form monocalcium, dicalcium and tricalcium saccharate, depending upon the working conditions.

The saccharate mainly formed in the cold is the monocalcium and this is soluble only with difficulty in 200 parts of water and almost insoluble in a solution of calcium hydroxide. It is therefore possible to filter off this compound after which the sugar may be freed by the simple application of carbonitation.

This method is used extensively in the beet-sugar industry and a modification of it is now coming into use in one of the newer processes of the cane-sugar industry.

Other processes.—Among the long list of other methods recommended for the extraction of sugars may be mentioned the "Norit," "Clarite," "Soxhlet," "Ranson," "Manoury," "Kopke," "Garthley," "Gordon," Electrolytical, Barium, Strontium, Hydrogen-peroxide and Phosphoric Acid.

Principles of manipulation and reagents.—It will be observed that the methods available to the manufacturer for the making of high-grade sugar directly from the raw material are numerous and that the general principles involved are identical in many of them, but specific attention is given to temperatures, acidities, alkalinities, clarifying reagents and time of their application, as well as a careful chemical control of each part of the work. One who thinks of building a plant for the manufacture of white sugar or changing his present plant to one of that kind should carefully consider the class of raw material he will use and his working conditions, before deciding upon any particular method.

METHODS USED TO IMPROVE RICE CULTURE IN THE PHILIPPINES.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

From 1894 to 1896, while the "Boletin Oficial Agricola de Filipinas" was being published monthly by the Spanish Government, many interesting and valuable reports were made of public record. Very little, however, is to be found in the three volumes on the subject of rice culture. There are accounts of fertilizer experiments and cultural tests, and 151 varieties are named. (See this REVIEW, Vol. I, 1908, No. 8, p. 307.)

Following the harvest of the rice crop of 1908, three Filipino agricultural scientific assistants who had been educated in the United States were detailed on the work of collecting data relating to rice culture as practiced in these Islands, and securing samples of seed of varieties.

In the thirty provinces visited, 828 samples of seed were secured and 2,430 variety names listed.

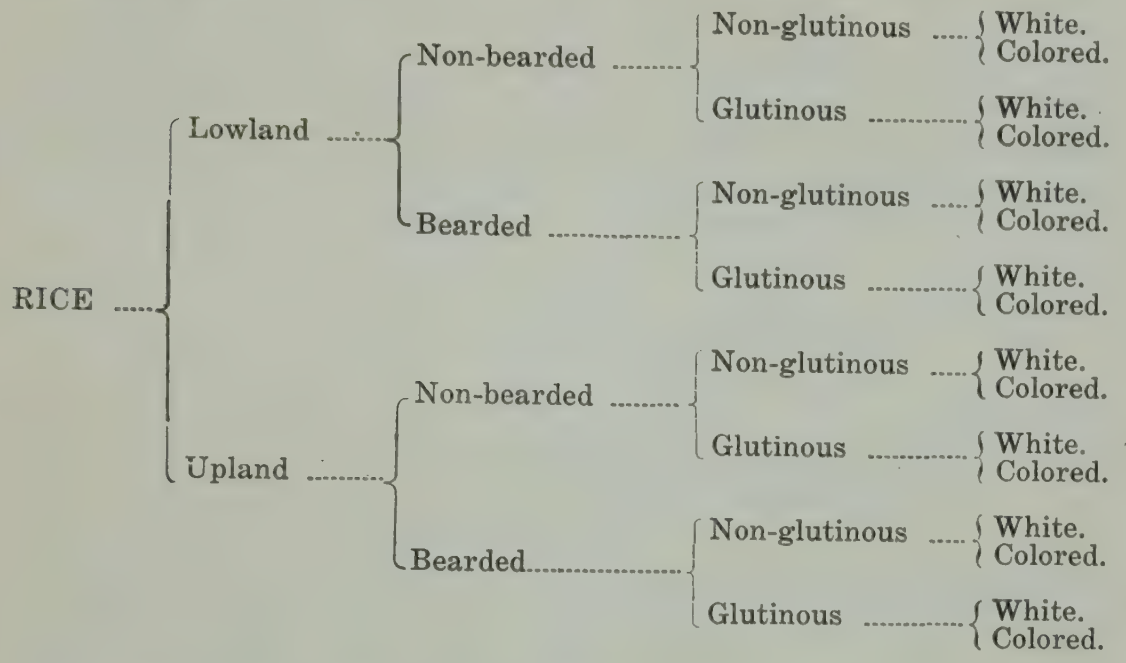
From the samples then on hand 200 so-called varieties of lowland rice and 56 of upland rice were selected for comparative tests. The seed-beds of the lowland varieties were sown in June, 1909, at the Alabang stock farm, and the upland varieties were planted immediately thereafter.

This was the beginning of systematic rice work and was directed by the then Acting Director of Agriculture, Prof. Charles M. Conner.

A big problem was the devising of means for identifying varieties so that all duplicates could be eliminated early, and for providing a general scheme for classification. First of all, the varieties were divided into two large classes according to adaptability, upland (or highland) and lowland.

Each of these was subdivided into two classes according to presence or absence of awn. These in turn were further divided according to composition of kernel as glutinous or nonglutinous, and the resulting classes into others according to the color of cuticle.

The classification fell into sixteen groups, as a hypothesis, as indicated below.



As a matter of fact it was found that for practical purposes a much lesser number of classes was necessary, as will be shown later. On the other hand the classification could have been extended *ad infinitum* without adding to the value of the scheme. A very comprehensive classification scheme was devised later by S. Kikkawa, of the Tokyo College of Agriculture. (Vide Vol. III, No. 2, Journal of the College of Agriculture, Imperial University of Tokyo, Sept., 1912.)

There are on record 1,011 varieties which have been tested out and identified. Of these, 158 have been found to be duplicates.

The remainder is found in thirteen classes as follows:

Lowland:

118—Bearded, non-glutinous—white.
162—Non-bearded, non-glutinous—white.
19—Bearded, glutinous—white.
3—Bearded, glutinous—colored.
8—Bearded, non-glutinous—colored.
2—Non-bearded, non-glutinous—colored.

Upland:

307—Non-bearded, non-glutinous—white.
45—Non-bearded, glutinous—white.
1—Bearded, glutinous—white.
6—Bearded, non-glutinous—white.
46—Non-bearded, non-glutinous—colored.
35—Non-bearded, glutinous—colored.
1—Bearded, non-glutinous—colored.

For convenience, of the varieties with kernels having colored cuticle, sub-divisions were made, one of red and the other black. Thirty-three varieties were found in which the color of the cuticle was so deep that it could not be called red, and for practical purposes it did not matter if the deeper colored ones were merely a deep-dull purple or some other color closely resembling black, hence the term applied was deemed sufficiently accurate. The varieties were classified as follows:

Lowland:
- 2—Non-bearded, non-glutinous—black.
- 4—Bearded, non-glutinous—black.
- 1—Bearded, glutinous—black.

Upland:
- 8—Non-bearded, non-glutinous—black.
- 17—Non-bearded, glutinous—black.
- 1—Bearded, non-glutinous—black.

It will be noted that neither a non-bearded, glutinous white, nor a non-bearded, glutinous colored variety was found among the lowland rices, while 45 of the non-bearded glutinous white, and 35 of the non-bearded glutinous colored, were found among the upland rices, but no example of bearded glutinous colored, of which there were three among the lowland rices.

It should be understood that classification of rice into two big classes of lowland and upland may be a somewhat arbitrary matter. We have found that there is much confusion among farmers and others as to what is the proper classification for a given variety.

According to our definition an upland variety is one which is either sown broadcast, or planted in hills or drills, on soil which is prepared in a dry state. The preparation of the soil and the planting are done as would be the case if oats, wheat or barley were to be grown. Irrigation may or may not be practiced. Here we do not irrigate such rice. Varieties suitable for culture under these conditions are characterized by much larger, and somewhat broader leaves. Compared with strictly lowland varieties the leaves of upland varieties are 41 per cent longer and 20 per cent wider. (See this REVIEW, Vol. VI, 1913, No. 2, page 91) The surface of the leaves of upland varieties are usually smooth to the touch while those of lowland varieties are catchy. Upland varieties may be regarded as being less sensitive to drought than lowland varieties.

Lowland varieties are such as are planted in soil which is puddled in preparation. The seed may be sown broadcast on the field or the seedlings transplanted thereto. Many people

are confused when they find lowland rice grown at altitudes approaching a mile and upland rice grown only a few feet above sea-level.

We have found varieties which may be grown successfully under strictly upland culture and as well when transplanted in puddled soil, and they may also be grown fairly well when sown broadcast on such soil. One of the best varieties of rice yet found appears to be perfectly suited to lowland conditions, yet in many districts it is grown and known only as an upland variety. Many upland varieties do not thrive in puddled soil and literally "drown" when planted in paddies.

There is a great difference in the behaviour of lowland varieties when sown broadcast in puddled soil, some seeming to be much better suited for such treatment than others.

For culture under the "dapog method" as described in this REVIEW, Vol. VIII (1915), No. 2, a very high mortality of seedlings is experienced with some varieties when transplanted at the early age required by this method.

At the beginning, it appeared that nothing was more important than to learn the relative values of varieties with special reference to yield and quality of grain. As a consequence plot testing of varieties was carried out on a quite comprehensive scale. The lowland varieties were grown in three provinces on different types of soil and under different climatic conditions, yet the relative positions of varieties did not differ much when the reports of the respective stations were compared. With varieties being grown in duplicate plots in three differing districts the results obtained were deemed to be reasonably dependable. This would hardly be the case with upland varieties, with which the water supply was not under control.

The plot-testing work is briefly outlined below:

Year.	Number of varieties.	
	Lowland.	Upland.
1909	200	56
1910	381	365
1911	400	474
1912	128	247
1913	130	247
1914	47	44
1915	61	53

When the 1913 and 1914 crops had been harvested, there were data on record showing the performance of many varieties over a period of five years. Naturally, a large mass of data

[Face.]

ORYZA SATIVA **VAR. NAME:** _____ **WHERE FOUND:** _____

ADAPTABILITY: { Highland / Lowland **GRAIN:** { Awned / Awnless **HULL:** { Solid color / Non-solid color **KERNEL:** { Glutinous / Non-glutinous **CUTICLE:** { White / Colored **AGE:** { Heading _____ days. / Maturity _____ days.

TESTED AT _____ **DATE** _____ **GROWER** _____

CULTURE: { Highland—broadcast, drill, hill (caiñgin) / Lowland—broadcast, transplanted (age of seedling _____ days)

CONDITIONS: Soil _____ Fertilizer _____

Moisture: { Irrigation / Rainfall in inches—1st mo. _____, 2d mo. _____, 3d mo. _____, 4th mo. _____, 5th mo. _____, 6th mo. _____, 7th mo. _____ **Temperature:** { max. _____ °C. / min. _____ °C.

PLANT—

YOUNG PLANT: { Number of leaves / Height to tip of leaves _____ cm. (28 da. old) **COLOR:** { of trunk / of blades { of base of blade / of edges of blade { of ligule / of auricle

AT HEADING: UNIFORMITY: { not uniform, fairly uniform, medium, very uniform **COLOR:** { of anthers / of stigma { of empty glume / of awn

{ of grain / of tip of grain { of culm / of node { of sheath: int. sf. _____, ext. sf. _____ / of blade: up. sf. _____, low. sf. _____

{ of base of blade / of edges of blade { of ligule / of auricle **HEIGHT:** _____ cm. **GROWTH:** erect, medium, open, very open.

FOLIAGE: { Nature: stiff, heavy, medium, weak. / Abundance: scanty, medium, abundant. **BLADE:** { Upper surface: scabrous, catchy, smooth. / Lower surface: scabrous, catchy, smooth. { Midrib: scabrous, catchy, smooth. / Edges: scabrous, catchy, smooth. { Length _____ cm. / Width _____ cm.

AT MATURITY: RIPENING { not uniform, fairly uniform, medium, very uniform. **STOOLING:** { Number of culms / % of bearing culms **CULM:** { Length _____ cm. / Diameter **Color** { int. surf. / ext. surf.

Wall of Culm { thin, rather thin, medium, rather thick, thick. **Node** { Average number per culm / Color **FOLIAGE: Color of Sheath** { int. sf. / ext. sf.

{ of blade: up. sf. _____, low. sf. _____ / of base of blade { of ligule / of auricle **RACEME:** { Length _____ cm.; close, rather close, medium, rather open, very open. No. spikelets on base

Ave. no. of spikelets per raceme _____ Ave. no. of grains per raceme _____ **GRAIN:** { single or bunching / 2, 3, 4, 5, 6. **Shape** { Outline: orbicular, oval, elliptical, oblong, lanceolate, oblanceolate, ovate, obovate. / Thickness: granular, cylindrical, thin, medium, plump.

{ Length _____ cm. / Width _____ cm. { Color of body / Color of tip **HULL:** { thin, medium, thick; glabrous, scabrous, somewhat hispid, hispid, very hispid. **EMPTY GLUME:** { Length (relative to grain) / Color

AWN: { Length: v. short, short, medium, long, v. long. / Color **KERNEL:** { Length _____ cm. / Width _____ cm. **Color** { cuticle: / endosperm: v. white, white, dirty white, blackish, reddish, amber.

Density of Endosperm: partly vitreous, greatly vitreous, vitreous, greatly white or chalky Aroma and Flavor; non-aromatic, aromatic, very aromatic % of hull to grain by weight **SPECIFIC GRAVITY:** { Paddy / Clean rice

YIELD PER HECTARE: { Liters _____. Wt. of 75 liters paddy _____ K. / Kilos _____. Wt. of 75 liters cl. rice _____ K. **SHATTERING QUAL:** { very easy, easy, medium, tight, very tight. **MILLING QUAL:** { poor, fair, medium, good, very good.

REMARKS:



(a) In the background, a selected variety of rice in bloom; in the foreground, an ordinary variety due to bloom in two months, provided the rainfall is sufficient.



(b) A cooperator and his rice plot.

BUREAU OF AGRICULTURE

RICE POSTER

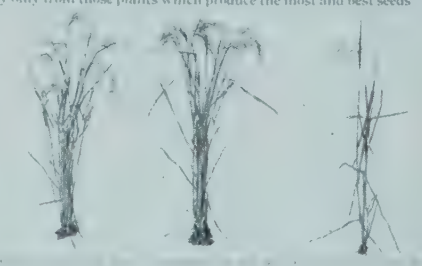
SELECT YOUR SEED PALAY IN THE FIELD AT HARVEST TIME

In order to produce a good crop of palay, good seed must be planted. Good seed can only be obtained by selecting the seed while it is still on the plant. The seeds on each palay plant are the children of that plant. When these seeds are planted, they will in turn produce plants like the plants upon which they were borne. Therefore, it is most important to select the seed palay only from those plants which produce the most and best seeds.

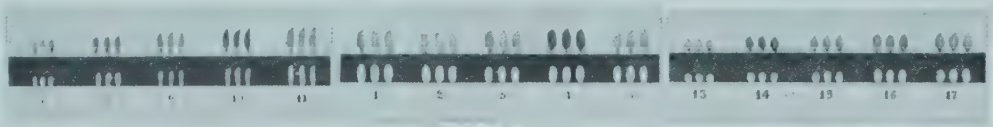


WHAT IS A GOOD PALAY PLANT?

A good palay plant is one which produces five or more stalks, each stalk bearing a head of medium size, each head containing plump, well-matured kernels. All the heads of a plant should be borne at a uniform height above the ground.



WHAT IS A GOOD KERNEL?



A good kernel is one that is white, nonglutinous, and free from dents and creases. In size it should be about twice as long as it is wide and as thick as possible. Extreme sizes must be avoided. The kernel should be clear in appearance, semitransparent; kernels which appear cloudy or contain much soft starch are not desired. When kernels have white spots on one side, seed should be taken which has these spots of the smallest size. Light-colored hulls are most desirable.

WHEN SHOULD SEED PALAY BE COLLECTED?



Seed palay should be collected just before the crop is ready for harvest. At this time one can study the plants in the field and pick seed only from good plants.

HOW SHOULD SEED PALAY BE SELECTED?

Go into the field just before harvest and search for good palay plants. When such a plant is found, cut off ALL the heads, leaving a sufficient length of straw on each head for convenient handling. Be very careful to collect heads which are as nearly alike as possible.

Give much attention to securing early-maturing palay. In most places it is not profitable to plant a variety which needs more than four months to mature after transplanting.

Collect more heads than you think you will need; these may be made into small bundles for convenience. Dry them carefully and thoroughly, suspended in a sheltered place. All heads must be ripe when collected. Avoid unripe plants.



WHAT SHOULD BE DONE AFTER THE SEED PALAY IS GATHERED?

It is very important to remove all the heads containing colored or red grains from the seed palay.

After the harvest work is completed and there is spare time, the final selection of the seed palay should be made. Pick the heads one by one and hold them up against a bright light. Red kernels are easily detected by this method in varieties having light-colored hulls. If the hulls are dark colored, open one grain in each head. If one kernel is colored, all the kernels of that head are also colored. Discard all heads containing red kernels.

Selection may also be extended by discarding all heads containing kernels which show the undesirable characteristics previously mentioned.

WHAT SHOULD NOT BE DONE?

Do not save seed from a plant bearing but one good head—no matter how excellent it appears to be.

Do not save seed heads from plants which have weak or broken-down stalks.

Do not select seed heads near the edges of the field; such plants may appear better than they really are, because they have had more space in which to develop. For the same reason do not select seed heads from a plant which stands by itself in the field.

The heads which are to be retained for seed may either be suspended in bundles in a dry place, protected from mice, rats, and birds, or threshed and stored.

IS IT IMPORTANT TO SAVE GOOD SEED PALAY?

There is nothing more important or more profitable to the rice grower than to properly select his seed before harvest time and carefully guard it. Carefully selected seed will produce larger crops per hectare and of better quality at no greater expense to the rice farmer. Any farmer who wishes to increase his yield of palay will carefully select his seed palay this year and every year.

Poster distributed throughout rice-growing sections. This poster was also printed in Spanish and the five principal native dialects.



(*a*) Farmers visiting the "Rice Special." During its trip through the provinces more than 30,000 visitors were received by the men in charge.



(*b*) Modern agricultural implements carried by the "Rizal Special;" these received considerable attention.



(*c*) Visiting farmers testing the implements exhibited on the "Rice Special."

138070——4

[Back.]

NOTE.

For the purpose of securing uniformity of results, the following notations should be observed:

GENERAL.

1. Much of the accuracy of this work depends on the amount of good judgment exercised in making the field observations and in gathering the samples for the laboratory:
   (*a*) Work on the average; but
   (*b*) If there is a very wide variation, note also the limits—i. e., the maximum and the minimum, viz: 0 to 3, 2 to 5, $\frac{1}{6}$ to $\frac{2}{3}$, medium to long (or very long), etc.

FIELD.

1. Height of young plant—measured from the ground to the common ending of most blades.
2. Length of culm (should not be taken before the plant has fully headed out)—measured from the ground to the base of the raceme, which may or may not have spikelets.
3. Diameter and thickness of culm—to be observed during ripening or at maturity at a point about 3 or 4 cm. below the uppermost sheath-node. Average of 10 culms.
4. Dimensions of leaves—to be taken from the *second* blade from the top. Average of 10 leaves.
5. Stooling—By this is meant the average number of culms developed from each original grain or seedling, and is to be expressed in figures, as 2, 5, 7, 8, 10, 16, or whatever the number may be. This observation should be taken at or after the heading period.

LABORATORY.

1. Length of raceme—measured from its base (which may or may not have spikelets) to the tip of the uppermost flowering glume. Average of at least 5 heads.
2. Length of awn—under 2 cm., very short; 2 to 4 cm., short; 4 to 6 cm., medium; 6 to 8 cm., long; and 8 cm. or longer, very long. (Sometimes it is necessary to express the length thus: very short to short, medium to long, or other combinations.)
3. Length of empty glume—This is expressed in fractional numbers with relation to the grain to which it is attached, viz: $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{5}$, 1, $\frac{6}{5}$, etc.
4. Length and width of the grain or kernel—The average of 10 grains or kernels.
5. Color of cuticle—The most common colors are: White, creamy white, red, light red, salmon, light brownish-red, light reddish-brown, black, purplish-black, *partly* black (or purplish-black) and red (or light red, brownish-red, reddish-brown, etc.).

were on file from which valuable information could be deduced. Unfortunately, there has been no opportunity as yet to put this material into shape for publication.

The very important matter which received early attention was to provide a scheme for the positive identification of each variety.

An identification card (pp. 194, 195) was accordingly devised by Silverio Apostol, agricultural inspector, which served very well for the purpose. With use, the card has become modified somewhat, but in the main it has been sufficiently elaborate to cover all points for observation, deemed essential.

Due to the elimination of duplicates, 165 lowland varieties were planted at the Alabang stock farm in June, 1910, which had been grown there during the preceding season and 216 varieties which had been secured from various sources during the year.

Of upland rice, 365 varieties were planted at the Lamao experiment station, as it was believed that the conditions there were more suitable for upland rice. At each of the stations the observations were made and recorded by a man trained in such work.

In 1911, 400 varieties of lowland rice were continued in plot tests at the Alabang stock farm, and at another station established on the Luisita Estate, San Miguel, Tarlac, Tarlac, where the tests were duplicated. At the Lamao experiment station, 474 varieties of upland rice were handled in plot tests.

In the treatment of lowland varieties the following rules were observed. The seed was sown in nursery beds one square meter in area. At transplanting time the seedlings were taken only from the center of the nursery bed. The duplicate plots were 1.5 by 10 meters in dimension and on these plots the seedlings were set out, singly, spaced 25 centimeters apart in the rows, the rows also 25 centimeters apart.

Every precaution was made to provide identical conditions for all the varieties being tested.

With the accumulated data on hand covering three years of work with rice, Prof. Conner wrote Bullettin No. 22, entitled "Rice Culture in the Philippines." This bulletin contains a brief sketch of the work which had been done, and lists 25 of the highest-yielding white non-bearded non-glutinous, and 12 white bearded non-glutinous lowland varieties, also 25 upland white non-glutinous non-bearded varieties, and general instructions on rice culture.

Altogether, 910 varieties had been collected, 452 lowland and 458 upland. Of these, 134 lowland varieties and 6 upland were bearded.

From page 32 of Bulletin No. 22, the following extracts are taken:

> There seems to be very little difference in the average yield of those (varieties) maturing in 140 days as compared with those maturing in 186 days. * * *
>
> Of the total number of white, non-glutinous, non-bearded lowland varieties tested, 33, or 20.6 per cent, gave an average yield of less than 1,000 kilos of palay per hectare; 58, or 36.2 per cent, ranged between 1,000 and less than 2,000 kilos; 69, or 43.1 per cent, ranged between 2,000 and 3,400 kilos.
>
> Of the bearded varieties of this same class, 5, or 4 per cent, gave an average yield of less than 1,000 kilos per hectare; 66, or 53.6 per cent, ranged between 1,000 and less than 2,000 kilos; 52, or 42.3 per cent, ranged between 2,000 and 2,800 kilos.
>
> Of the red, non-glutinous, non-bearded lowland varieties, 6, or 12.7 per cent, gave an average yield of less than 1,000 kilos per hectare; 19, or 40.4 per cent, ranged between 1,000 and less than 2,000 kilos; 22, or 46.8 per cent, ranged between 2,000 and less than 3,000 kilos.

Generally speaking, a variety which averages less than 2,000 kilos rough rice per hectare in yield is unprofitable, hence, according to the above statement more than one-half of the lowland varieties were unprofitable.

A puzzling feature of the work constantly encountered was the appearance in many cultures of rice with colored cuticle, in spite of all efforts made to exclude them. Another point was the relatively low yields obtained when compared with possible yields. It should be stated, however, that low yields were in part attributable to the quality of the soil at the Alabang stock farm, which is very deficient in organic matter and somewhat lacking in several mineral elements. If rice lands were classified into three grades it would fall within the limits of the middle grade.

In order to conclusively eliminate all red rice from the seed to be used in the 1912 plot tests, the transparency test, as used in Indo-China, was applied to all the seed, and all kernels having red or reddish cuticle were removed.

During the year, a test to determine the most suitable spacing of hills in the paddy was made; also a test with lowland varieties of varying requirements as to time to mature, planted in January so as to mature during the hot season, from which conclusions were drawn that no variety requiring more than 150 days to mature was suitable for this purpose; and two comprehensive fertilizer tests which were inconclusive. A limited number of farmers were also induced to plant small amounts of seed of the varieties known to be most productive.

A large number of varieties were eliminated from the plot tests

in 1912. Only 128 varieties of lowland were planted at the Alabang stock farm, and the upland rice work was transferred from the Lamao experiment station to the La Carlota experiment station where 247 varieties were planted in the plot test. A substation for testing lowland varieties was located on the Roxas Estate in Laguna Province.

Of the lowland varieties included in this season's operations, 90 had given an average yield for two years or more exceeding 2,000 kilos per hectare of rough rice.

Other tests conducted were as follows: a test to determine the effect of the age of seedlings at transplanting time upon yield; a test to determine proper distances at which to space hills of transplanted rice and the proper number of seedlings per hill; and, a test to determine the proper quantity of seed to use on a given area of nursery seed bed to insure maximum vitality of seedlings.

The writer, formerly detailed on investigations concerning corn, took up the matter of selection work with rice and when the 1912 crop was being harvested, made selections for planting the succeeding season. This work has been briefly alluded to in an article published in the Philippine Agricultural Review, Vol. VII (1914), No. 9, page 346.

It was realized that the method of beginning with a single grain might prevent handling somewhat larger amounts of material, but the possibility of more rapid progress in using the entire heads is of such value that the head-to-the-row method was adhered to.

Considerable study was made of the probable effects of water temperatures on rice-plant growth, and as an outcome of this work further studies were made on the effects of water-supply on growth.

In 1913, 130 varieties of lowland varieties were carried in plot tests at the Alabang stock farm and on the Roxas Estate, Calauan, Laguna, and 247 varieties of upland rice at the La Carlota experiment station.

The other lines of investigation pursued during the preceding year were continued.

During 1914 the number of varieties continued in plot tests was considerably reduced. Only 47 varieties of lowland varieties were continued in culture at the Alabang stock farm and on the Roxas Estate and 44 varieties of upland rice at the La Carlota experiment station.

Several hectares were devoted to seed propagation of varieties which had been subjected to careful "mass selection" for years.

The extension of pedigree work required considerable area. The investigations with regard to the features of rice culture, as outlined for 1912, were continued.

Two special features of the work with rice were developed during the year.

The field agents operating in various rice-producing provinces were supplied with the best seed, which had so far been produced by the plant-industry division. This seed was put up in small canvas sacks holding three liters, and specific planting intructions were supplied on a printed slip of paper which was placed in each parcel.

The field agents secured farmer coöperators to cultivate these varieties of rice on small plots located in the fields which they were planting with the usual varieties. (Plate XI, *a*, *b*).

In round numbers, 1,200 farmers took hold of this proposition, and did the work under the field agents' supervision. Last season was a trying one for most rice varieties, especially the more prevalent sorts which require 180 days to mature. Practically no rain fell after October first and large areas dried up and were not harvested.

The abundant yield of the small plots planted with selected seeds was, in many cases, far beyond the most sanguine expectations. Again and again reports were submitted, showing that in fields shriveling on account of the drought the small demonstration plots were yielding, in farmers' parlance, at the rate of from 60 to 100 fold.

When it is borne in mind that the average yield for these Islands was but 18.26 cavanes to the hectare for 1914, a yield of from 60 to 100 cavanes was really notable. In most cases no further demonstration was necessary to convince the farmers of the value of better seed. The disposition of surplus seed of these varieties was a somewhat difficult matter. Many farmers had more seed than they needed for the ensuing season's planting and the local rice millers offered a premium over market prices for this surplus, consequently much valuable material which should have been carefully saved for seed was disposed of otherwise.

The drought tended to center public attention on the question of the selection of more suitable and more productive varieties for general planting, and this office initiated an educational campaign on the subject of the importance of seed selection and methods to be employed.

The slogan was "Select your seed (palay) in the field at harvest time."

There are many instances on record of corn-growing com-

munities conducting campaigns, directed along lines to promote the proper selection of seed corn. We have heard of "Seed-corn days" and "Seed-corn weeks," but we believe this is the first instance of a campaign to induce the farmers to select seed of any small grain in the field. The field agents were engaged in this work throughout the harvest season and through their efforts large amounts of seed were carefully selected, properly dried, and stored.

An illustrated poster was prepared and the text printed in English and Spanish, as well as in five of the leading dialects (Plate XII). Altogether, ten thousand posters were sent out and posted in public buildings, such as provincial and municipal government headquarters, public markets, railroad stations and other places where the people congregate in numbers. Posters were also distributed to the public schools throughout the Islands to the number of 4,300. These were all in the English language.

The Director of Education, Mr. Frank L. Crone, sent instructions to the division superintendents of schools, to the effect that "The information contained therein (on the posters) should be taught to the pupils as a part of their regular work." Some division superintendents responded with enthusiasm and even went so far as to lay out a definite course of instruction, based on the poster, to be followed by the teachers. One instance is on record where eight lessons were arranged to be given each class so that the subject matter would be thoroughly mastered.

Preceding the planting season of 1915 a rice-demonstration train was sent through the principal rice-growing territory. (Plate XIII, *a*.)

This train consisted of a passenger coach, remodeled so as to provide means for properly displaying seeds, photographs and charts. Farmers were invited to bring samples of their seed rice to this coach where a trained man would meet them and discuss the merits of the samples and other varieties. A flatcar was attached to this coach and on it were mounted engines and pumps designed for small irrigation plants (Plate XIII, *b*). Plows, harrows, cultivators and other small implements were also carried and actual field operation of each demonstrated (Plate XIII, *c*). In the evening an illustrated lecture was given on the subject of improvements of rice culture.

This outfit made a stop of a whole day at each place and traversed the principal rice-producing regions and received approximately 30,000 visitors on the tour.

Prior to the planting season the demand for seed of early maturing varieties of rice, made upon the Bureau of Agriculture, was far beyond its ability to supply, but approximately 5,000 farmers secured varying quantities of seed for planting. It was also deemed essential to secure a more comprehensive test of the four new pedigree varieties which had been evolved and several hundred farmers volunteered to give them a trial.

At the time this is being written harvest reports are coming in which amply prove that the confidence placed in these new strains has been justified and that they are regarded with keen appreciation by the growers. In one strain we have found a remarkable stiffness of straw and in another a habit that is quite as valuable. This other strain when blown down by high winds promptly proceeds to put the panicle in an erect position so that the grains are less likely to be damaged by the flood water.

Interest in seed selection is growing to such an extent that the field agents now find much of their time taken up during the harvest season by the farmers who desire to be shown how to select their seed rice for the next planting. Many of these farmers have seen the value of this work demonstrated before their eyes in a manner which leaves no room for doubt. This office has emphasized the importance of good seed and has given this topic precedence over all others, due to the fact that the poor and unsuitable seed ordinarily planted contributes more than any other factor to the poor average yields obtained in the Philippines.

Another point to be considered is the fact that the average farmer is averse to making radical changes in his methods, nor is he in a position to purchase fertilizers, but by using better seed he can produce much larger crops, without upsetting any of the usual practices.

A very small percentage of the rice lands are under irrigation, and little of the remainder can be irrigated except through large and expensive plants, which are beyond the means of the land owners, unless such projects are supported and directed by the Government.

This office has as yet done but little work on the problems involved in the fertilization of rice soils. With a small force it is better to do one thing at a time, attacking the most vital problems first.

Considerable study has been devoted to the subject of the proper distance at which to space hills of seedlings in the field, the proper number of seedlings to put in each hill, the age at

which seedlings should be transplanted, and the area of seed bed to be used for a given amount of seed.

Uniformity of practice with regard to the details mentioned above does not prevail here, as in China, for instance. Practices differ widely in neighboring districts, and the prevalent tendency is to space hills too closely and to put too many plants in the hill. Usually the seedlings are left in the seedbed too long.

In the opinion of the writer, plot testing with varieties which are subjected to "mass selection" as Dr. Nilsson uses the term, are of importance principally as a means of keeping a fresh stock of seed on hand and a possible source of an occasional remarkable mother plant.

With us, it is cheaper to carry a considerable number of these varieties in plot culture than it would be to go out searching for the variety whenever it might be desired. The varieties now carried may serve another purpose as well, for, being the best varieties remaining out of several hundred, their combined records are a yearly check with which we can compare the performance of the new lines. We are constantly on the watch for the exceptional mother plant. Every man engaged in rice work is repeatedly admonished, to look for such plants at all times.

We are not planning to go into hybridization work in the immediate future, since we have a wealth of undeveloped or uninvestigated material which may yield lines far surpassing anything hoped for. In fact, we are confident that within at least one of the so-called varieties from which we have already extracted a superior strain we shall find material for a still better one.

The line-breeding work, begun by the writer with rice, has been adapted from the methods employed in the amelioration of cereals and other cultivated plants at the Svalöf Experiment Station in Sweden.

Since we had the plot tests of varieties planted with but one seedling in the hill, the selection of mother plants was a simple matter, compared with making selections of plants in fields where a number of seedlings were set in the hill. It is preferable to run a sharp cutting instrument just beneath the surface of the soil to sever the roots so that the entire plant may be removed. Pulling the plant frequently results in injury. If a careful inspection is made of the kernel beforehand, but few plants need to be taken which are likely to be discarded later. Each plant is subjected to a careful scrutiny and when it is to be retained for a mother plant, it is given a permanent number,

and the panicle on the central culm removed and placed in a small envelope, numbered to correspond with the plant. The plant is then accurately described and all data pertaining to it recorded in a permanent file. This data should be sufficiently in detail so that, if the plant is damaged or destroyed, a sound basis for comparison is still to be had.

With lowland rice there need be little doubt about the uniformity of the fertility of the soil of the test plot since a plot of 25 x 25 meters is easily made and the soil can be thoroughly mixed and reduced to a uniform condition, and the plot made so level that uniform distribution of water will be insured. We have used plots 10 x 25 meters in interior dimension, and with proper precautions the use of plots of this size need not increase the probable error. Our preference is for plots with a surplus margin of 50 to 70 centimeters as a border next to the dikes on which extra plants may be grown to be discarded at harvest time. Thus if the line of 100 plants has three extra plants properly spaced on each end and is the fourth row from the dike, the influence of position near to dikes will not be apparent. Usually it is the two outside rows which benefit by the preferred position next to dikes.

At harvest time the entire row is harvested excluding of course the plants at the ends of the rows. Each plant has a band of raffia tied about it and is severed from its roots at the surface of the soil. All the plants of the row are tied into a bundle and the row marker (a stake) is included therein. After the curing is completed each bundle in turn is spread out for inspection. A comparison made with the data concerning the mother plant or with the mother plant itself, usually indicates the probable value of the line. Quite frequently, this cursory view is sufficient to determine the fact that the mother plant has not produced progeny even remotely resembling itself in productivity and the line is set aside forthwith.

If the line passes the first test, the heads of each plant are snipped off at the base of the panicle and placed in a standard envelope. Then all the envelopes with contents are weighed, the tare subtracted and the net weight divided by the number of plants in the line. It may be well to number the plants with easily attached labels and the envelopes to correspond so as to avoid any confusion which may arise due to clumsy handling, but if the work is done in an orderly systematic manner the numbering may be omitted.

The test by gross weight usually disposes of a majority of the lines. Those that pass this test will have the envelopes con-

taining the panicles attached to the respective plants and will then be subjected to the careful scrutiny, measurements and counting that is necessary to find the modes and a basis for consistent comparison.

The first year's work with the lines does not afford a good opportunity to observe their performance when subjected to high winds. We have not devised laboratory equipment to test the breaking strength of straw, and regard the field test as more dependable, on account of the several factors involved.

For the second year we have employed a method which some regard as unnecessarily comprehensive. From the lines which are finally retained, the central panicle is taken from twenty plants thereof which are usually above the mode for the essential characters. The remainder of the seed from these twenty plants is mixed together and constitute a primary check sample. The seed from the remaining plants is taken and mixed together and constitutes a secondary check sample. Thus in the second year the mother plant is represented by a unit of twenty rows of 100 plants each; each of these rows represents one of the twenty supernormal plants of the first line, a primary check plot in duplicate being planted with a composite sample of seed from these plants and a secondary check plot in duplicate being planted with a composite sample of seed from remaining plants of the original line. The figures which result from this triplicate system of checking, if properly done, leave little chance for making any serious mistake in the final choice of lines. If there is any doubt about the merits of a given culture it may be carried in the plot test, so as to avoid losing the seed, until such time as the doubt is settled.

During the second year a good opportunity is afforded to observe such things as stiffness of straw, and tolerance of dry, hot weather. After the second year, the cultures should be on such a large scale that the hectare yields may be based on sufficiently large units to obviate the frequent errors which result in compiling yields from small plots.

In our experience, we have pushed the propagation of the most promising lines so that at the end of the second year we have on hand a considerable quantity of seed. If then the second year's work proved the correctness of the theory based on the first year's work, an area of several hectares might be planted in the third year.

We have several supporting facts behind us in proceeding in this maner. To begin with, the mother plants are taken from mass cultures of which we have a dependable record for a period

of 3 to 6 years and the margin of difference between the average yield of the plots of mass selections and the yield of the line cultures frequently amounts to the astonishing figure of from 50 to 200 per cent. Thus if the duplicate plots of the mass-selected culture yields an average of 0.75 kilos per 100 plants and the line cultures yield double or treble that amount, there is little chance in making serious mistakes in choice. Another very important feature is the permanent elimination of the kernels with colored cuticle, not to mention the uniformity of ripening and other features. Even though no gain in productivity should result the other improvements are worth far more than the effort and expense incurred.

Regarding the so-called new varieties it is our preference to withhold final judgment until they have been grown in large cultures for not less than five years. For the immediate future, however, we feel justified in being less conservative.

Another feature of the rice work in 1915 was the arrangement entered into by the plant-industry division of the Bureau of Agriculture with some of the students of the Central Luzon agricultural school, for the purpose of having pure seed rice propagated on an extensive scale. This school is known as a farm school and in it besides the academic work the students are obliged to labor on the school farm.

A considerable body of the school boys were divided into two classes; one known as the Special Rice Growers and the other body as the Independent Farmers. Each of these classes has elected a secretary who is the representative of the class in its relations with officials of the Bureau of Agriculture.

Improved seed in quantity was furnished the boys who agreed to grow the crop according to instructions with which they were supplied.

Through their secretary each class submits monthly reports on progress of work and status of the various rice varieties which reports are always acknowledged by the Director of Agriculture or the chief of the plant-industry division, sometimes asking for more detailed information or offering comments.

It is understood that when the rice crop is ready for sale the Bureau of Agriculture will purchase it at a premium above the market price, since the grain will be handled in such a manner as is most suitable in the treatment of high-grade seed.

The school boys have entered into the business with keen interest and even though the odds have been against them at times, they have striven valiantly to overcome them.

At one time, while the rice plants were quite young, locusts

appeared and threatened to destroy the miniature rice farms, but the principal of the school, appreciating the seriousness of the situation, declared a holiday and the entire schoolbody went against invading locusts and managed to save the rice with but little damage.

When these students who have been carefully cultivating this rice crop make delivery thereof to the purchasing agent of the Bureau of Agriculture, they will be paid therefor as would any other businessman in a transaction of this nature, and this money is the student's to keep or to spend for such things as he requires in his school work.

The rivalry between the two competing bodies is wholesome and effective and the interest in varieties which is created leads to criticism of their respective merits which leaves little to be desired.

MYRTACEOUS POSSIBILITIES FOR THE PLANT BREEDER.

By P. J. WEBSTER, *Horticulturist in Charge of Lamao Experiment Station.*

PRELIMINARY REMARKS.

In an article published in this REVIEW last year by the writer, a brief survey was made of the plant material available for plant improvement in the Tropics, and attention was called to the excellent opportunities for original work for the plant breeder in the equatorial belt.[1] Going more into detail, another article was previously published in this REVIEW enumerating and briefly describing 49 species belonging to the family *Annonaceæ* that may be utilized in plant improvement work.[2] In that paper the writer stated that "it is doubtful whether there is any other genus which contains so many species having edible fruits as the genus *Annona,*" enumerating 21 species of that genus with edible fruits, and recognizing a total of 31 edible species in the family *Annonaceæ.*

Since then a bibliographical study of the myrtaceous plants has brought to light the astounding fact that this large family contains no less than 64 species with edible fruits, of which 20 belong to the genus *Psidium* and 19 to *Eugenia,* with scattered species in 13 other genera.

While pains have been taken to exclude all doubtful species and synonyms, it is nevertheless probable that a comparative study of the European and American herbaria would establish the synonymy of some of the species hereinafter enumerated. On the other hand, it is practically certain that if more complete data were available relative to many species not included in this list, and the descriptions of which are anything but complete, they would, in all likelihood, be classed among the fruit-bearing plants, not to speak of still unknown species of which

[1] "Opportunities in Plant Improvement in The Tropics;" see this REVIEW, Vol. VII (1914), No. 3, p. 123.

[2] "Annonaceous Possibilities for The Plant Breeder;" see this REVIEW, Vol. VI (1913), No. 7, p. 312.

there must be many in the vast, unexplored Brazilian hinterland. In the botanically comparatively well-known Philippines two edible Eugenias have been described within the last four years. (*E. curranii* C. B. Rob. and *E. calubcob* C. B. Rob.)

Of the genera under discussion, some, like the *Eugenia,* extend over the Tropics in both hemispheres, and several species of this genus were therefore known and described by the early European travelers in the East. Other genera, like *Britoa* and *Psidium,* are confined to the American Tropics and subtropics. It is true that some species of *Psidium* have been reported from Asia, but it is safe to say that these species had been previously introduced there from America. Brazil is the home of more species belonging to the *Myrtaceæ* (46) with thremmatological possibilities than any other country; Australia contributes one species.

Commercially the most important species is unquestionably *Bertholletia nobilis* Miers., as the source of the Brazil nut, but as soon as the virtues of the sapucaia become better known we may expect this to rival the Brazil nut. The most important among the fruits is the guava, which is also the most widely distributed species. A close second to the guava in value is the jaboticaba, and, judging from the most recent account of this fruit, the jaboticaba, when better known, and introduced into other parts of the Tropics, will, in the future, take a prominent rank among the tropical fruits. The feijoa is also a fruit of unusual merit, the cultivation of which is rapidly spreading in southern France and California.

The guava, strawberry guava, cattley guava, feijoa, macopa, duhat, yambo, pitanga and jaboticaba are the only species in cultivation, for all practical purposes, though, as may be noted in the descriptive list, there are several others that have been more or less domesticated. The guava, pitanga and feijoa are the only ones that have been propagated vegetatively, until recently it was demonstrated at the Lamao experiment station that the duhat, yambo and lipoti could be shield budded.

The fact that three of the species—jaboticaba, lipoti and duhat—are used in the manufacture of wine, coupled with the fact that grapes do not thrive well in the Tropics except at high altitudes, brings up the interesting speculation as to whether we may not among the *Myrtaceæ* find desirable substitutes for the grape for the Torrid Zone, principally, of course, for a wine industry, but also as a dessert fruit. In Brazil the jaboticaba is used for both purposes. Considering that three are used for wine making, it seems certainly probable that among so many

related species there are several others that also would possess wine-making qualities.

Broadly speaking, the annonaceous fruits, because of their large sugar and starch content, are valuable as an actual food, in contrast to the myrtaceous fruits, which, with the exception of the Brazil nut and the sapucaia, find their chief uses as dessert fruits, or in the manufacture of preserves and jellies.

The notes used in the preparation of this article, which has been prepared with a view of calling the attention of horticulturists and breeders to the available plant material among the myrtaceous plants, were collected in 1910 in Washington, D. C., when the writer was connected with the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry, United States Department of Agriculture, but lack of time to put them into printable shape has until now prevented their publication. Unfortunately the available descriptions of the fruits of a large number of species in the botanical literature consulted are very incomplete, frequently merely stating that the fruit is edible.

DESCRIPTIONS AND COMMENTS.

1. *Aulomyrcia obovata* Berg.—An arborescent shrub, indigenous to Brazil, attaining a height of 6 meters, bearing small, dark purplish, subacid, 1–4 seeded, edible fruits.

2. *Bertholletia nobilis* Miers.—Brazil nut. A tall tree, exceeding 33 meters in height, indigenous to tropical Brazil and Guiana; fruit almost spherical, 9 to 12 centimeters long, consisting of a hard shell containing 18 to 24 three-angled nuts.

Bertholletia excelsa H. B. K. was formerly considered as a source of the Brazil nut, but this has recently been shown to be an error.

3. *Britoa acida* Berg. (*Psidium acutangulum* DC.).—A tree, 6 to 9 meters high, indigenous to the interior of Brazil along the upper Amazon River; fruit quite large, of the size of a small apple, spherical, pale yellow, smooth, with acid pulp.

4. *B. sellowiana* Berg.—Casacas. A tree attaining a height of 6 to 8 meters or more, native of Brazil; fruit 2 centimeters in diameter, subglobose, yellowish, and edible.

Closely related to the guava.

5. *B. triflora* Mart.—Ibabiraba. A tree, indigenous to tropical Brazil, with a fruit of about the size of a cherry, brownish; flesh whitish and edible.

6. *Campomanesia aromatica* Griseb. (*Psidium aromaticum* Aubl.).—Citronelle. A small tree, 4.5 or more meters tall, indigenous to the West Indies and Guiana; fruit of about the size of a cherry, spherical, yellowish, aromatic and edible.

7. *C. coerulea* Berg.—A small shrub, 1 to 2 meters tall, with glaucous foliage and edible fruits, indigenous to Brazil.

8. *C. corymbosa* Berg. (*Psidium corymbosum* Cambess).—Guabiroba. A small, erect shrub, 1.5 meters tall, native of Brazil; fruit rotundate, yellowish and of good flavor.

9. *C. fusca* Berg.—An arborescent shrub, 5 to 6 meters tall, with edible fruit, indigenous to Brazil.

10. *C. lineatifolia* Ruiz et Pavon. (*Psidium lineatifolium* Pers.).—Palilla. An arborescent shrub, attaining a height of 4 meters, indigenous from Brazil to Peru, in which latter country it was already in cultivation 100 years ago; fruit 3.5 centimeters in diameter, pyriform, yellow and edible.

11. *C. multiflora* Berg. (*Psidium multiflorum* Cambess).—A small, erect shrub, 1 meter tall, with an edible fruit, native to Brazil.

12. *C. obversa* Berg.—An arborescent shrub, 6 meters in height, indigenous to Brazil, bearing edible fruits.

13. *C. reticulata* Berg.—An arborescent shrub, indigenous to São Paulo, Brazil; fruit about the size of a cherry, yellow, aromatic and well flavored.

14. *C. transalpina* Berg.—A tree, bearing a well-flavored fruit, indigenous to Brazil.

15. *Eugenia aquea* Burm.—Tambis. A small tree with turbinate, frequently seedless, edible fruits; indigenous to Indo-Malaysia, including Mindanao in the Philippines. Sometimes cultivated.[1]

16. *E. brasiliensis* Lam.—Grumichama. An arborescent evergreen shrub, attaining a height of from 4 to 6 meters, native of Brazil; fruit about 2.5 centimeters in diameter, spherical to oblate, crowned by a prominent persistent calyx, exterior dark red to purple, smooth and shining; flesh sweet and of agreeable flavor.

The grumichama is rarely seen outside of Brazil.

17. *E. calubcob* C. B. Rob.—Calubcub. An arborescent shrub or small tree, attaining a height of 6 to 8 meters, indigenous to the Philippines; fruit ellipsoid to ovoid, greenish white, fleshy and edible.

18. *E. curranii* C. B. Rob.—Lipoti (Plate V, *a*). A tree, attaining a height of 9 meters or more, with gnarled trunk and tortuous branches, evergreen; fruit congregated in clusters on the branches and mature twigs; individual fruits, 12 to 20 millimeters in diameter, spherical, smooth, dark red to black; skin very thin; flesh red next to skin, interior white, rather dry, crisp, acid and of pleasant flavor. Indigenous to the Philippines where it is rarely cultivated. Season April to June.

Eaten raw and used in making a wine by the native inhabitants.

19. *E. dysenterica* DC.—Cagateira. A shrub, 1 to 5 meters tall, or a tree, with edible, lemon-colored fruits, native of Brazil.

20. *E. gardneriana* Berg.—A shrub, 2 meters high, or a tree, with dark-red to blackish fruits, edible. Indigenous to Brazil.

21. *E. guabiju* Berg.—Guabiju. A tree, attaining a height of 6 to 9 meters, bearing an edible fruit, indigenous to Brazil.

22. *E. itacolumensis* Berg.—An arborescent shrub, 4.5 meters tall, with

[1] The writer is indebted to Dr. E. D. Merrill, Botanist, Bureau of Science, for descriptions of *E. aquea*, *E. mananquil* and *L. zabucajo*.

ovoid, 2 centimeters long, one-seeded, edible fruits. Indigenous to Minas Geraes, Brazil.

23. *E. jambolana* Lam.—Duhat. A large, spreading tree, attaining a height of 8 to 15 meters; leaves oval to elliptic or obovate elliptic, leathery and shining; flowers numerous, in panicles, axillary or terminal; fruit ovoid to ellipsoid, 1.5 to 2.25 centimeters long, dark purple to black, smooth, thin skinned, fleshy, juicy, subacid, well flavored, and containing one seed.

The fruit makes a superior jelly. The duhat is indigenous to the eastern Tropics and is as yet only sparingly introduced in other parts of the Tropics. A wine is prepared from the duhat in India.

24. *E. jambos* L.—Yambo. An arborescent shrub, or a tree, sometimes attaining a height of 12 meters, indigenous to Malaysia; leaves lanceolate, dark green, leathery and shining; fruit 2.5 to 4 centimeters in diameter, ovoid to spherical, cream colored, smooth; flesh sweet and crisp, dry and well flavored, with a peculiar odor and aroma of roses, which has in some parts of the Tropics given the fruit the name "roseapple" or "poma rosa."

The fruit may to advantage be used in flavoring jelly and related products made from other fruits. The yambo is fairly well introduced into the West Indies, but is less common on the mainland of the Western Hemisphere.

25. *E. javanica* L.—Manquil. A tree, attaining a height of 12 meters; leaves elliptic-oblong, subsessile, dark green. The fruit is 3 to 4 centimeters long, turbinate, smooth, pinkish and very attractively colored; the flesh is white, dry, sweetish, without distinctive flavor, tasteless and of poor quality.

The manquil is without doubt the "waterapple" figured in Plate IX, in "Fruits of the Hawaiian Islands" by G. P. Wilder, who states that in Hawaii the fruit of this species attains the remarkable length of 12.5 centimeters. The manquil is indigenous to Malaysia and is but sparingly introduced into other parts of the Tropics.

26. *E. klotzschiana* Berg.—Cabacinha. A small shrub, 1 to 2 meters tall, indigenous to Brazil, with an edible fruit of the size of a small pear.

27. *E. malaccensis* L.—Macopa. An attractive tree, attaining a height of 10 to 12 meters, with elliptic-oblong to broadly oblong-lanceolate, dark green, coriaceous leaves, indigenous from India to Malaysia, but fairly well introduced in the West Indies and Hawaii. The fruit is subglobose to obovoid, 3 to 4 centimeters long, smooth, dark red; flesh white, subacid, and pleasantly flavored, but rather dry and of inferior quality.

28. *E. mananquil* Blanco.—Midbid. A sylvan, tall tree, 7 to 20 meters high with prominently veined leaves, indigenous to the Philippines. The fruits, borne in great profusion on the trunk and large branches, are about 4 centimeters long, ovoid, red, fleshy, acid and edible.

E. whitfordii Merr. is a closely allied form of *E. mananquil.*

29. *E. myrtifolia* Sims.—A shrub, 2 to 4 meters tall, native of Australia.

The fruit is about 1.8 centimeters in diameter, red or violet colored and edible.

Seldom seen outside of its native country.

30. *E. nhanica* Camb.—Nianica. A tree, indigenous to Minaes Geraes, Brazil, with a fruit about the size of a medium-sized prune, red, smooth, shining, edible, 1 to 4 seeded.

31. *E. pyriformis* Camb.—Uvalha. A small tree, native of São Paulo, Brazil. The fruit is of about the size of a prune, pyriform, yellow, velvety, edible.

32. *E. uniflora* L. (*E. michellii* Lam.).—Pitanga. A shrub, indigenous to Brazil, attaining a height of 6 meters, with ovate-lanceolate, glabrous leaves. The fruit is 2.5 centimeters in diameter, sub-globose in outline, deeply ribbed longitudinally, dark red, to almost black, smooth and shining; flesh juicy, subacid and of good flavor, resinous when not thoroughly mature.

Comparatively rare outside of Brazil.

33. *E. uvalha* Camb.—Uvalha. A shrub, native of São Paulo, Brazil, where it is cultivated. The fruit is pyriform, of the size of a small pear, yellowish, acid and well flavored, and 1 or 2 seeded.

34. *Feijoa sellowiana* Berg.—Feijoa. A bushy shrub, attaining a height of 3 to 4 meters, with obtusely elliptical leaves, thick and leathery, dark green and shining above, grayish and puberulent beneath, flowers axillary, solitary or in clusters. The fruit is 4 to 6 centimeters long, oblong or ovoid, green, surface smooth, furrowed longitudinally, rough, skin thin; flesh white, granular, sweet, juicy, highly aromatic, and of excellent flavor and quality, seeds very small, embedded in the flesh.

The Feijoa is indigenous to Southern Brazil, Paraguay, Uruguay, and Northern Argentina, and has been introduced to Southern France and Italy, Hawaii and the West Indies. It is a fruit of unusual promise, but is subtropical rather than tropical, and will probably succeed only at high altitudes in the Tropics.

35. *Gomidesia sellowiana* Berg.—A shrub, sometimes exceeding 3 meters in height, indigenous to tropical Brazil. The fruit is small, globose, scarlet, sweet and edible, 1 to 4 seeded.

36. *Lecythis zabucajo* Aubl.—Sapucaia. A tree, 25 meters or more high, with oblong-lanceolate, entire, acuminate leaves, and terminal pendulous racemes of white and pink flowers. Fruit ovoid, about 15 centimeters in diameter, containing numerous furrowed nuts about 5 centimeters long and 2.5 centimeters across. Indigenous to Guiana and adjacent territory in Brazil.

37. *Marlieria tomentosa* Camb.—Guapuronga. A shrub, indigenous to São Paulo, Brazil. The fruit is of about the size of a cherry, black, tomentose, and of good flavor.

38. *Myrciaria jaboticaba* Berg.—Jaboticaba. A spreading tree, attaining a height of 10 to 12 meters, with ovate-elliptical to lanceolate leaves, native of Central Brazil. The fruit is produced on the stem, branches and twigs, not unlike the Philippine lipoti, 12 to sometimes exceeding 25

millimeters in diameter, spherical or slightly oblate, dark maroon purple, glossy and smooth, skin thicker than that of the grape, tough; flesh white or tinged with rose, translucent, vinous, and of good flavor, seeds 2 to 4.

The jaboticaba was known to Piso and Marcgrav, and has been domesticated in Brazil, where the fruit is very popular, and where the tree is cultivated to some extent. The fruit is eaten out of hand, and fermented makes a good wine. Two other species of *Myrciaria, M. trunciflora* Berg. and *M. cauliflora* Berg., are known under the vernacular name "Jaboticaba." These species present minor differences from each other and from *M. jaboticaba,* and when closely studied all will probably be included as varieties of a common species.

39. *M. tenella* Berg.—Macia. A shrub, 2 to 4.5 meters in height, indigenous to tropical Brazil extending to subtropical South America. Fruits small, globose, dark purple, fleshy, subacid and well flavored, 1 to 2 seeded.

40. *Myrhinium atropurpureum* Schott.—Murtilla. A shrub, native of Brazil, bearing ovoid, 2 to 4 seeded, edible fruits.

41. *Myrtus mucronata* Camb.—A small shrub, 1 meter tall, with spherical, polyspermous, edible fruits of the size of the cherry, indigenous to Northern Argentina, Uruguay, and Southern Brazil.

42. *M. ugni* Molina.—Ugni. A tree, attaining a height of 30 meters, indigenous to Chile. The fruit is purple, glossy, edible, and of agreeable flavor.

43. *Psidium arboreum* Vell.—A tall tree, indigenous to Brazil, with solitary flowers and pyriform, well-flavored fruits, 2.5 centimeters in diameter.

44. *P. basanthum* Berg.—A dwarf shrub about 30 centimeters tall, native of Brazil. The fruit is globose, 2 centimeters in diameter, greenish and edible.

45. *P. cattleianum* Sabine. (*P. obovatum* Mart, ex DC., *P. littorale* Raddi, *P. variabile* Berg., *P. coriaceum* Berg.).—Cattley guava. A shrub or small tree, attaining a height of 6 meters, with dark-green, leathery, shining leaves, indigenous to Brazil. The fruit is subglobose, up to 3.5 centimeters in diameter, claret red, smooth; flesh reddish near skin, interior white, juicy, subacid, sweet, aromatic and of good flavor, seeds many, small.

The cattley guava is quite hardy, and is cultivated to a considerable extent in California and is also grown in Florida and South Europe. The yellow cattley guava (*P. c.* var. *lucidum* of some writers) should perhaps be raised to the rank of a separate species.

46. *P. cinereum* Mart. ex DC.—A shrub, native of Brazil, bearing an ovoid edible fruit.

47. *P. cuneatum* Camb.—A shrub, indigenous to Brazil. The fruit is about 2.5 centimeters in diameter, pyriform, greenish, glabrous, punctate; the flesh is of good flavor and contains few seeds.

48. *P. dulce* Vell.—A tree, native of Brazil, with solitary, spherical fruits, 3.5 centimeters in diameter; flesh sweet and edible.

49. *P. firmum* Berg.—A small shrub, 30 centimeters tall, with edible, subglobose to ovoid fruits, native of Brazil.

50. *P. friedrichsthalianum* Ndz.—Cos. A tree, indigenous to Central America, attaining a height of 8 to 12 meters; the fruit is small, subrotund, very acid, and is said to make a superior preserve and jelly.

51. *P. grandifolium* Mart. ex DC. (*P. albidum* Camb.).—A shrub with large, obovate leaves, glabrous above; the fruit is 3 centimeters in diameter, globose, greenish, almost glabrous, the flesh is well flavored. Indigenous to Brazil.

52. *P. guajava* L. (*P. fragrans* Macf., *P. aromaticum* Blanco, *P. cujavillus* Burm., *P. sapidissimum* Jacq., *P. pyriferum* L., *P. pomiferum* L.).—Guava. An arborescent shrub, attaining a height of 6 meters, indigenous to Tropical America. Leaves oblong to elliptic with prominent veins, flowers axillary, 1 to 3, white. Fruit variable, spherical to obovoid and pyriform, from 3 to 7.5 centimeters in diameter, greenish yellow to almost white, smooth, skin very thin. Flesh extremely variable in all characteristics, in color from pure white to various shades of yellow and red, in acidity and sweetness from very sweet to extremely acid, or to lack of both, resulting in an insipid, flavorless fruit; in good varieties the flesh is juicy, tender and excellently flavored. The seeds are usually numerous, but seedling trees are found now and then that are almost seedless.

The guava is one of the most widely distributed of the tropical fruits, readily adapts itself to new soil and climatic conditions, and usually naturalizes itself wherever introduced. The fruit makes a very superior jelly and canned fruit, and a good guava makes an excellent dessert fruit eaten with sugar and cream.

53. *P. guineense* Sw. (*P. araca* Raddi, *P. dichotomum* Weinm.).—Araca. A shrub, indigenous from the West Indies to Brazil. The fruit, produced 1 to 3 in the axiliary buds, is 1 to 2 centimeters in diameter, subrotund, greenish yellow, sparsely pubescent, flesh variable in color, red to white, and of excellent flavor.

According to Martius the araca is the Aracá-iba of Piso and Marcgrav, and was cultivated in Santo Domingo, West Indies, as early as 1788. Nevertheless, and notwithstanding its excellent quality, the araca is still rare in cultivation.

54. *P. incanescens* Mart. ex DC.—A shrub, indigenous to Brazil, upwards of 2 or more meters high; the fruit is about 2.5 centimeters in diameter, subglobose, green, and of good flavor, containing 4 to 5 seeds.

55. *P. microcarpum* Camb.—A small shrub, native to Brazil, with subrotund, greenish fruits, 1.2 centimeters in diameter, of good flavor.

56. *P. molle* Bertol. (*P. monticolum* Berg.).—Guisaro. A small shrub, indigenous to Central America and Mexico. The fruits are small, seldom exceeding 18 millimeters in diameter, spherical, smooth, yellowish; the flesh is yellowish white, juicy, rather acid, of excellent flavor, and quite aromatic.

57. *P. montanum Sw.* (*P. cordatum* Sims., *P. amplexicaule* Rich., *P. aromaticum* Desc.).—A tall tree, sometimes attaining a height of 30 meters, with hard wood and rigid branches, growing from sea level to an altitude of 1,800 meters. The flowers are large, white and fragrant, and the fruit

of about the size of a cherry, globose, greenish, pubescent, aromatic and of good flavor.

P. montanum is indigenous to the West Indies, and was domesticated as early as 1816 in the islands of Guadeloupe and Saint Croix. Still it is even yet seen sparingly in cultivation even in the West Indies, and is very rare in the eastern Tropics.

58. *P. ovoideum* Berg.—A dwarf shrub, upwards of 1 meter high, with greenish-yellow, edible fruits, indigenous to Brazil.

A very variable species.

59. *P. pohlianum* Berg.—A plant with ovoid, yellowish, glabrous, edible fruits, 2 to 2.5 centimeters in diameter, indigenous to Brazil.

60. *P. polycarpon* Lamb.—A small shrub, rarely exceeding 1 meter in height, indigenous to tropical America. Many-flowered; the fruit is of the size of a large cherry, yellow, of delicate and good flavor.

61. *P. radicans* Berg.—Uvaca. A small, erect shrub, with an edible fruit, native of Brazil.

62. *P. suffruticosum* Berg.—A shrub, 2 to 3 meters tall, indigenous to Brazil, with subglobose, green fruits, 2 centimeters in diameter, edible.

63. *Rhodomyrtus tomentosa* Wight.—A shrub, 2 meters or more tall, indigenous to the southeastern mainland of Asia. The fruit is about 2 to 2.5 centimeters in diameter, globose or ovoid, dark purple, flesh sweet and aromatic and well flavored.

This species has been sparingly introduced into the West Indies.

64. *Rubachia glomerata* Berg.—Cambuca. A tree, indigenous to Brazil. The fruit is of the size of an apricot, yellowish, 1 to 2 seeded and edible.

The cambuca was in cultivation in Rio de Janeiro over fifty years ago, but seems never to have been introduced abroad.

CORN IMPROVEMENT IN THE PHILIPPINES.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

In 1910 it was estimated that 288 thousand hectares of corn were cultivated in the Philippine Islands, returning an average yield per hectare of 8.56 cavanes.

The figures for 1914 show 421 thousand hectares devoted to corn and an average yield of 14.87 cavanes per hectare, an increase in area of 46 per cent and an increase in yield per hectare of nearly 74 per cent.

These large increases are significant, especially the marked improvement in yield per hectare, particularly when the fact is known that the increase in yield has not been influenced in the slightest degree by the introduction of foreign varieties, but has been effected solely by the improvement of native varieties, and the practice of better cultural methods.

The figures gathered by the statistical division of the Bureau of Agriculture show steady advancement in area cultivated, and yield.

Fiscal year.	Area cultivated, hectares.	Average yield per hectare.
1910	288,268	8.56
1911	302,516	8.22
1912	340,196	10.78
1913	383,709	11.31
1913 [a]	394,648	12.55
1914	421,309	14.87

[a] Calendar year.

This steady progress is encouraging, but it is realized that only a beginning has been made. The highest average yield of 14.87 cavanes per hectare does not compare favorably with the average annual yield obtained in the United States, which is 29 cavanes per hectare for a forty-five year period.

The extension of the area devoted to corn culture is due to several causes: for example, the two droughts which have cut down the production of rice, which has in turn caused the farmers to plant corn more extensively as a secondary crop; the education of the people in the methods of preparing corn for

human consumption; the realization too, that corn is fit and proper for such purposes; and, as a direct response to the interest shown by the Government in the extension of corn culture.

One of the great obstacles to overcome has been the prejudice of the people who have been so long under the domination of the European idea that corn is fit only for feeding animals. This attitude finds expression in apologies offered when corn in some form is set before the guest, the inference being that the host is at least tacitly admitting poverty when he fails to provide rice.

This attitude is less frequently encountered now, as the people are learning that corn is both a wholesome and proper food for all classes of humanity.

On two of the densely populated islands of the Archipelago, the people have become corn eaters, since natural conditions have forced this situation upon them.

In the selection of varieties, color prejudices on the part of the farmers are met with as frequently here as in other parts of the corn-growing world. The more common contention is that yellow corn is more nutritious than white.

Another prejudice which for a while was not as carefully heeded as it should have been is the farmer's strong preference for a strictly flinty type of kernel. This preference is quite justifiable when it is remembered that the greater bulk of the crop is consumed as human food, the kernels cracked or made into "grits" and then cooked in much the same manner as rice. Any variety of corn which contains a considerable portion of soft starch is not so suitable for making grits, since in the cracking process the soft starch crumbles, and is finally sifted out and can be utilized only for feeding animals. Very many people who buy corn for food have no animals to consume this waste. In addition, it has been found that the softer dent varieties are preferred by the weevils, hence are damaged by them more quickly and completely.

Corn is grown throughout the year, provided there is sufficient moisture present in the soil, and the same strain or variety which is planted at the beginning of the rainy season is also planted toward the end of the rainy season.

Consequently, it will be readily seen that extremely different demands are made upon the same variety. When the corn is planted at the beginning of the rainy season, it is subjected to the maximum rainfall and minimum sunshine, but when it is planted towards the end of the rainy season the crop is subjected to a limited rainfall with ample sunshine.

Anyone who is familiar with the requirements of the corn plant

will anticipate that maximum yields of corn will be produced from the planting made toward the end of the rainy season, and this is actually the case. Surprisingly satisfactory results, however, are frequently secured when the crop is grown under less favorable conditions.

The most prevalent error in culture is overcrowding, so that normal development is prohibited. Over-crowding has its support in the belief that the more plants on the hectare the more grain will be produced, and besides that, the ground will be shaded sufficiently to retard weed-growth.

A practice that very materially reduces corn yield in the Philippines is the same one that is so persistantly adhered to in all corn-growing countries, namely, deep plowing instead of shallow cultivation, after the root systems are well developed. This destructive mode of cultivation is practiced in the culture of sugar-cane and tobacco, as well.

In seed selection the Filipino farmer frequently puts into practice a very good principle. He insists that a seed kernel should have a large "chit" or germ.

It is interesting to note in this connection, that the farmer has unconsciously selected a strain of corn which has tended to have a high protein content. According to Professor Willard, in Kansas Experiment Station Bulletin No. 197, it is quite possible to secure a high average protein content if large germs are selected, especially if the horny portion of the kernel is also large. Selecting seed with large germs also tends to increase the oil content, as has been shown by Dr. Hopkins of Illinois.

The following analyses made by the Bureau of Science show the composition of several types of Philippine corn.

Name.	Moisture.	Fat.	Carbohydrates.	Protein	Ash.	Crude fiber.
Laguna Yellow	11.34	4.96	72.91	7.96	1.20	1.63
Mexican June	11.46	4.94	71.52	9.28	1.46	1.34
Moro	11.60	4.81	69.76	10.50	1.54	1.79
Cebu Purple	11.00	4.38	71.61	10.17	1.03	1.81
Cebu White	11.50	4.42	70.94	9.45	1.73	1.96
Iloilo Yellow	11.69	4.89	73.18	7.88	1.33	1.03
Iloilo White	11.32	5.96	70.55	9.10	1.53	1.54

Analyses which have been made of American dent varieties have shown relatively low oil and protein content, though the evidence on hand is not conclusive. The Philippine native varieties are as a rule very similar in composition to the flint corns grown in the United States.

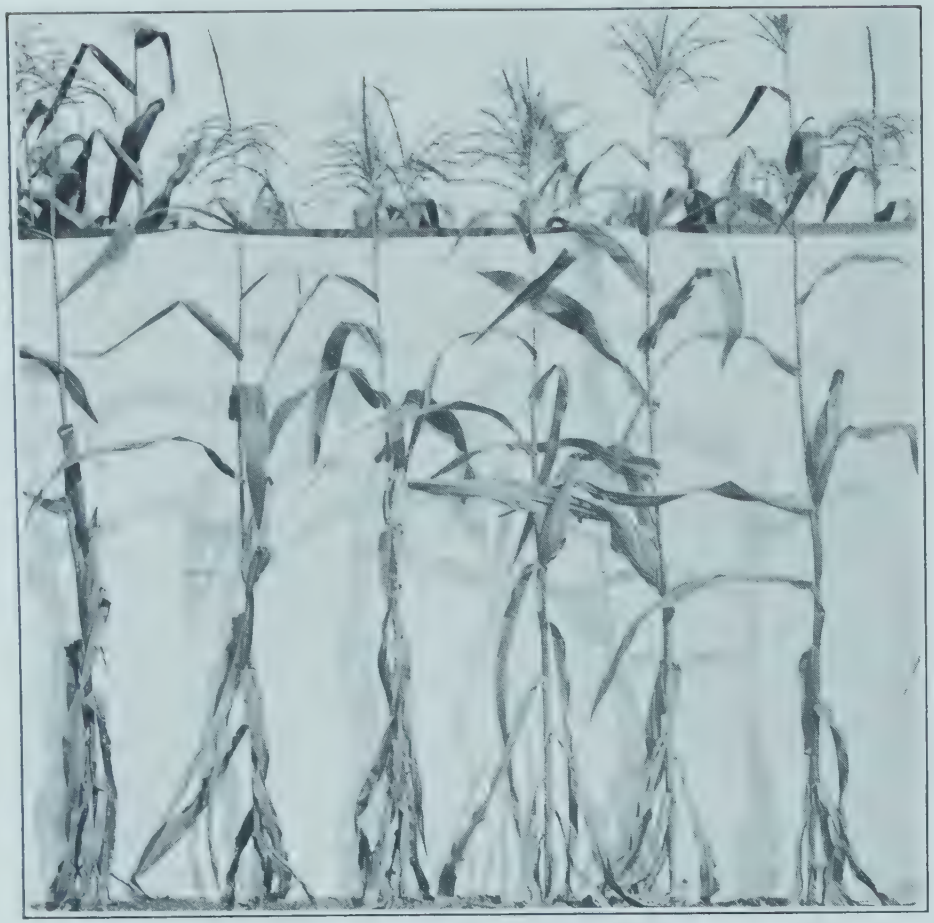
Some isolated regions have produced distinctive types of corn so that in a fertile valley a large type may be found, while in an



(*a*) Representatives of the types found in a good culture in an ear-to-the-row test. First generation.



(*b*) A selected ear from a common strain of native white corn compared with a selected ear from the fourth generation of native white corn improved by means of systematic seed selection. Both ears were derived from identical stock.



(*a*) A distinctive type of native white corn. Note the slender stalks and general lack of vigor.



(*b*) Another type of native white corn after being improved by ordinary selection methods. Note the thick, short-jointed stalks, large broad leaves and generally vigorous appearance, in contrast to the type shown in (*a*).



Native white corn. These are representative specimens from apparently homozygous strains produced by self-pollination in two generations.

upland country when the soil is poor a very small variety is cultivated.

As has been found in the United States, the highest production is usually secured with locally produced seed. It will also be found here, that with considerable differences in climate and soil fertility, it will be most profitable to develop local varieties of corn.

Native corn produced at 6° north latitude has apparently been insensible to the change, when moved north to 16° north latitude. This experiment has been repeated several times with no marked change taking place in the variety. On the other hand, but a slight change in enviroment has, in other experiments, produced unsatisfactory results.

American and Mexican varieties have at times behaved very strangely during the first season's culture, as is to be expected. Thus a variety planted at the beginning of the rainy season would prolong its growing period and become extremely rank, but if planted in the dry season would hasten to maturity and not even remotely reach its normal development. This is equally true of so-called Australian varieties.

The Mexican June variety of corn was introduced in 1908 and was successfully grown. While it did not "break up" as many introduced varieties do, it soon became quite different from the type it represents in the United States and in the course of five years became as flinty as the least flinty native varieties.

Since the native varieties produce the desired quality of grain, and are besides able to survive in varying and, at times, rather unfavorable environment, a thoughtful person would hesitate to throw away or disregard them. It is quite probable that these varieties, being largely the result of "the survival of the fittest," have a high degree of disease resistance and this factor is of paramount importance.

The chief criticism to be made on the native varieties is low productivity.

In the belief that the native varieties could be rapidly improved in the direction of productivity the writer began systematic selection work in 1912 and from that time up to the present no further attempt has been made to introduce foreign corn varieties. (Plate XIV, *a*, *b*).

In 1912 and since then extensive distribution has been made of seed of the larger and more productive types or varieties of native corn, which has undoubtedly had a marked effect in raising the average yield per hectare.

The first ear-to-the-row experimental plot was planted Decem-

ber 21, 1912. The seed ears selected were of the large-type white native variety. Large well-shaped ears only were taken but of two general shapes. One shape conformed as nearly as possible to the cylindrical while the other was distinctly tapering.

Sixty seven per cent of the seed ears had 16 rows of kernels, 25 per cent had 18 rows and the remainder had 20 rows of kernels. The number of kernels per row ranged from 36 to 45.

The longest ear measured 22.8, and the shortest, 20.3 centimeters. The circumference of all ears was taken at a point one-third of the distance from butt to tip and the greatest circumference was 18.4, and the smallest 16.5 centimeters.

The highest percentage of shelled corn on any ear was 84, the lowest 64. The average for the cylindrical shape was 81 per cent, and for the distinctly tapering 75 per cent.

In the field the rows were spaced 1.25 meters apart, and two kernels placed in each hill, spacing the hills 0.4 meter apart. Twenty days after planting the weaker plant was removed from each hill.

During the vegetative period the weeds were kept down by shallow cultivation and hand hoeing.

The first tassels appeared 54 days after planting and the first silks 57 days after planting.

The earliest maturing row required 88 days, and the latest maturing row 100 days.

All rows had an abundance of suckers as was anticipated, since the soil was moderately fertile and in good condition, and the plants given ample space, namely, 0.5 square meter each.

Data was taken on a large number of points, of which only a few are given here, because of lack of space.

Before harvesting, among other things observations were taken as to the point of attachment of the ear to the stalk and the following table giving the data taken on six rows selected at random throughout the plot is representative:

Row.	Node at which ear was attached.					
	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
A	4	22	52	22	0	0
B	4	31	43	20	2	0
C	2	28	51	19	0	0
D	2	17	36	37	8	0
E	1	11	42	41	4	1
F	8	31	44	15	2	0

As a general thing when the ear was borne at the sixth node, it was approximately on the middle of the stalk. This was the

case even though the internodal lengths varied considerably. Even on plants with short internodes, when the ear was attached at the seventh node, it was at such a height that the weight of the ear combined with the increased leverage caused the stalk to be more easily blown down.

Further data was taken and the figures given below fairly represent the variations found:

Row.	Sterile stalks.	Plants with one ear only.	Plants with two or more ears well developed.	Yield per hectare secondary ears.	Total yield.	Average weight per ear (primary).	Weight of seed ear.
	Per cent.	*Per cent.*	*Per cent.*	*Kilos.*	*Kilos.*	*Grams.*	*Grams.*
A	00.00	52.27	19.32	246	2,337	170	327
B	1.02	70.41	18.37	308	3,262	240	327
C	.96	69.57	7.62	80	2,125	166	272
D	0.00	40.78	28.16	410	3,080	217	272
E	0.00	40.26	33.77	472	2,756	186	288
F	0.00	37.76	29.53	288	2,960	217	302
G	2.65	35.40	23.89	434	2,488	167	272
H	0.95	34.95	12.26	118	2,593	201	802
I	0.00	69.72	12.75	78	2,778	219	295
J	0.00	43.75	44.79	111	2,694	210	303
K	0.00		54.00			196	319
L	0.00	14.38	64.71	750	3,920	258	288

It is estimated that 2.47 cavanes of ear corn will yield one cavan shelled corn; therefore, using 75 kilograms as the unit weight for one cavan, the yield expressed in cavanes ranges from 31 to 52 hectare.

The secondary ears, though mostly nubbins, yielded a percentage of shelled corn ranging from 63 to 75 per cent.

The most surprising result was the difference in yield when the product of the cylindrically shaped seed ears was compared with the product of the tapering seed ears. The latter yielded 25.9 per cent more shelled corn. This result is obviously due to several contributing causes. Williams and Welton, in Bulletin No. 282 of the Ohio Agricultural Experiment Station, show that "As an average of the 9 years' tests the tapering ears have been found to be 1.65 bushels per acre in the lead."

The chief fault with ears which were most cylindrical in shape was the bareness of the tip—an entry for several sorts of destructive insects. The tapering ears tended to have well-covered tips.

Seed ears for further planting were selected from three cultures, namely, "B", "F", and "L" and planted ear-to-the-row on April 9–10, but the rows were placed more closely than in the preceding test, namely, 1 meter apart, spacing the kernels so as to provide 0.36 square meter for each plant.

The increased yields are in part attributable to the closer spacing. The soil on which the crop was grown was in good

physical condition and well supplied with plant food, though not heavily fertilized.

Comparing the average yields of the seed ears according to the mother ears from which they were derived we find that "B" yielded 76.4 cavanes per hectare as an average of all cultures, "F" 96.2 and "L" 90.5. It should have been stated before that as a rule stout, short-jointed stalks of an average height of 3 meters, bearing broad leaves, were typical in all cultures. (Plate XV, *a*, *b*.)

This type of plant was particularly sought when the seed ears were selected.

While the above experiment was under way production tests under high culture were made, planting standard duplicate plots of $\frac{1}{25}$ hectare in area. On these the yields were 83.3, 118.9, and 151.2 cavanes per hectare, respectively, for each series. These plots were heavily fertilized, intensively cultivated and irrigated at regular intervals. This test was made in order to learn the extent to which production could be pushed in growing native corn.

In each ear-to-the-row test the half of each row was detasseled, alternating the ends. Thus the west half of row No. 2 was detasseled and the east half of row No. 3.

In the latter part of 1913 systematic production of seed of improved native corn was begun on one of the experiment stations, the plan being to plant a given area each month the year around. This was very successful and it became possible to obtain fresh seed corn with a high degree of viability at all times. In the Tropics, the germinating power of corn appears to be quite easily lost.

On the station selected for seed growing the weather conditions are more uniform than in many other places, the rainfall being distributed over a longer period, so that in a normal season it is possible to successfully plant one field and harvest another field of corn each month. The drought this year, however, was so severe that it was impossible to conserve sufficient moisture in the soil to germinate the seed during the hot season. It is usually possible on this station to see corn at all stages of growth from the newly planted to the mature corn ready for the drying kiln.

In a general way, the results obtained in the ear-to-the-row tests have been substantiated by the results obtained by agricultural inspectors in the field, by plantation managers and by others, who have found that by practicing seed selection in the

field, the yield of native corn has been rapidly and very markedly increased.

It is a common impression that the improvement of corn is a very simple and easy proposition, but that is true only in a relative degree. Because of its gigantic size when compared with other grain-producing plants it is easier to realize the differences in the individual characteristics of the corn plant. But, when one considers the infinite complexity of the genetic formula of a plant that is habitually cross-fertilized and hence hybridized to an extreme degree, it is exceedingly difficult to foresee the probable outcome of any selection and crossing that may be made. Especially is this true of a variety of corn which is the result of haphazard treatment through innumerable generations.

The most that the corn breeder who employs present accredited methods can hope for is to group similar types or strains, so that by continued grouping and crossing of similar individuals, the desired characters become emphasized to such a degree that the representative factors dominate in the genetic formula.

That this is the actual result is readily shown in any systematic breeding experiment. Frequently, in the most uniform and productive row there are a number of quite unlike and unproductive plants, and, as the work proceeds the proportion of these is lessened, but even with our purest strains of corn, unlike and unproductive plants occur with alarming frequency.

With corn, due to the stimulus of hybridization, a strain may appear to be much superior in some respects than it actually is. This is particularly true regarding size and productivity, but these characters are easily lost as soon as the genetic formula is again changed, as it usually does, in each generation.

The farmer who has been taught that "like produces like" is sorely puzzled when the progeny of a particularly fine plant presents as much variation apparently, as the progeny from a "scrub" plant.

The complexity of the corn plant is more easily realized when several of them, by means of self-pollination, are reduced to a more nearly homozygous condition, and with the object in view of obtaining more constant and definately known types for foundation stock for breeding work, five hundred ears of white native corn were collected as a portion of our corn work from various points in the Archipelago, and each ear planted in a row by itself. (Plate XVI.)

Roguing was begun early, and as a result, at the end of six weeks 20 per cent of the cultures were eliminated. At the time

that tassels were due to appear the range of variation presented was extremely large. One thousand plants were selected for self-pollination. The self-pollination was accomplished by means of a paper tube attached over the tassel and the other end of the tube fastened over the ear, employing the method described by G. N. Collins and J. H. Kempton, Bureau of Plant Industry, circular No. 89.

Only 124 cultures were retained for further planting, but shortly after these cultures were planted it became necessary to abandon the experiment, still general observations were made from time to time which disclosed striking features.

As to tassels, in some cultures they were very small with few branches, and in others the tassels were of unusual size and had profuse branches. Leaves varied greatly in color, size and position; on one culture the leaves clasped the stalk through their entire length, merely releasing the tips. The husks on the ears ranged from few in number to an excessive amount and on some the husks terminated in fully developed blades. Some cultures showed a purple color in a high degree.

Several cultures were remarkable in uniformity of all characters indicating a high degree of purity.

It is to be regretted that conditions did not permit the completion of this experiment since it would have supplied known parents of definitely known characters for the production of several distinct strains of native corn.

There has been little effort made to do research work with corn, as yet, since in the opinion of the writer, Collins, East, Hayes, Montgomery, Williams and others have supplied the corn-breeding world with ample scientific data so that progressive breeding work can be done intelligently.

Our problem here has been to find a suitable variety of corn, one that would be equal to the demands made upon it by local conditions, and that would be profitably productive. This has been done. It has been amply proven that almost any native type of corn can, by means of selection alone, if the work is progressively and intelligently done, be improved in productivity and quality to such a point that it will compare very favorably with improved corn varieties in other corn-growing countries.

Furthermore, progress will be more rapid in the adoption of better seed by the farmers since this sort of improved seed does not in any manner conflict with the farmers' prejudices. It conforms to his idea of color and composition and is in all respects similar to the seed he has been planting, but it has never-

theless greater productivity and consequently its future culture is assured.

It has been found easily possible to introduce and acclimatize a foreign variety of corn. In fact it takes no longer to acclimatize the foreign than it takes to improve the native sort, but unless the introduced variety has most of the good qualities of the native it will not be favorably received by the farmers. A multiplicity of varieties is quite undesirable in any crop in any community, and the danger of plant disease introduction, as an accompaniment of foreign seed introduction, is very real and ever-present. Therefore, it is the opinion of the writer that until the purpose and object of plant introduction is clearly seen, the amelioration of native varieties by selection is the most logical and safest course to follow in crop improvement, and, with only few exceptions, should be the policy of those who are entrusted with the work.

A YEAR OF AGRICULTURAL ORGANIZATION IN THE PHILIPPINES.

By MACK CRETCHER, *Superintendent of Coöperative Organization.*

In the campaign for advancement of agricultural conditions carried on through the office of coöperative organization of the Bureau of Agriculture during the past year, three great forces have been recognized. They are: Organization, agricultural education, and coöperation, and they follow each other in regular sequence. Organization is necessary in order to properly conduct a campaign of education leading to coöperation or united action on the part of the farmers.

Agricultural conditions in the Philippines are peculiar. Farmers are isolated. Mail and transportation facilities, although gradually improving, are as yet grossly inadequate. Lack of uniform language has retarded unity of thought and action. The average farmer has little or no knowledge of the principles of coöperation. He has been struggling with his problems unaided and alone. It is little wonder that in the majority of instances the methods employed are antiquated and the results often disappointing and discouraging.

Realizing the benefits of organization and the needs of agricultural education and coöperation, Honorable H. S. Martin, Secretary of Public Instruction, early in the year of 1914 initiated a campaign for uniting the farmers of the Philippines in an organization known as the Philippine Agricultural Society. The plan included the organization of a provincial or governing society in every province in the Islands, the membership to be composed of representative farmers from the municipalities of each province. Under the direction and supervision of these provincial agricultural societies, municipal agricultural societies were to be organized in each municipality. After the completion of this preliminary work, an Insular Agricultural Society was to be formed, its membership to consist of regularly accredited delegates from the various provincial societies. To facilitate the work of organization, the office of Coöperative

Organization was created in the Bureau of Agriculture, and Honorable Monico Mercado, ex-delegate from Pampanga, and the writer, were appointed as superintendents. During the month of June 1914 the preliminary steps were taken, including the drafting of tentative constitutions and by-laws to be used as a guide for the Insular, provincial and municipal societies, and the arrangement of an itinerary covering the leading provinces of Central Luzon. Copies of the constitutions and by-laws were printed not only in English and Spanish, but were also translated and printed in the leading provincial dialects, the more clearly to make known the objects of the proposed organization.

The first actual work of organization was begun with the organization of the Provincial Agricultural Society of Tayabas, which was perfected at Lucena, in that province, on July 7, 1914. Following this in rapid succession during the month of July, provincial agricultural societies were organized in the Provinces of Batangas, Laguna, Rizal, Cavite, Bulacan, Nueva Ecija, Pampanga, Tarlac, Pangasinan and Bataan, concluding with the organization of a society at Iba, Zambales, on July 31. The work was continued during the month of August 1914. The coast-guard cutter "Corregidor" was chartered and a tour of the southern provinces was arranged. During this trip agricultural societies were organized in the Provinces of Palawan, Capiz, Iloilo, Occidental Negros, Oriental Negros and Cebu. At Cebu, owing to an unfortunate accident to the engine of the coast-guard cutter, the boat was compelled to return to Manila for repairs and the remainder of the southern schedule was abandoned for the time being, except the Provinces of Albay and Ambos Camarines, which were reached by regular boat after returning to Manila, in time to attend meetings on the dates previously arranged. The society at Naga, Ambos Camarines, was organized August 25, 1914, being the last one for that month and the 20th society formed since the organizers started out on their work on July 7. The organizers met with the hearty support of the agriculturists in every province visited. The meetings were well attended and there was much interest and enthusiasm. Probably the largest meeting held was at Dagupan, Pangasinan, where 44 out of a total of 46 municipalities had representatives at the meeting which was held July 25. The total attendance was more than 450 interested farmers.

Upon returning to Manila from the southern organizing trip, the work having been well started, Mr. Mercado resigned his position as one of the organizers in order to give his entire atten-

tion to his law practice, and the work has since that time been continued by the writer, at times assisted by Honorable Adriano Hernandez, Assistant Director of the Bureau of Agriculture.

The work of organizing municipal agricultural societies occupied much of the time during the next few months. This work was done largely by the newly-elected officers of the provincial societies, under the direction of the office of coöperative organization in the Bureau of Agriculture. Copies of the constitution and by-laws, blanks for secretary's reports and instructions concerning organizing municipal societies were forwarded to the officers of the provincial agricultural societies and they were urged to at once take up the work of thoroughly organizing their provinces. The results were highly satisfactory. The unselfish, patriotic work of many of these officials deserves the highest commendation. They gave freely of both their time and their money in furthering the work. Some of the officers of the provincial societies visited every municipality within their jurisdiction, delivered lectures to the people, explained the benefits of the new movement and assisted in organizing the farmers in each locality. As a result, the office of coöperative organization was kept busy tabulating the reports of municipal organizations as they came in. By the end of November, 1914, over 150 municipal agricultural societies had been reported, and by January 1915 the total had increased to over 200. All this work was done by the provincial societies and their active officials at their own expense, as up to the present writing no money whatever has been received by any of these societies from the General Government.

As fast as the reports of these organizations were received they were entered in the permanent records of the office of coöperative organization, card indexed and alphabetically arranged by provinces, for ready reference. From time to time during the year the work of provincial organization has been extended, personal visits having been made by the superintendent to the Provinces of Samar, Leyte and Bohol, where provincial societies were established, and through correspondence and personal aid of leading agriculturists and officials, societies have been formed in the Provinces of Surigao, Mindoro, Masbate and Ilocos Norte.

A summary of the work of organization up to the time this article is written (September, 1915), a period of but little over one year, shows a total of 27 provinces in which provincial agricultural societies have been established, and under the direction of these parent organizations there are 265 municipal or branch

societies, the total membership exceeding 20,000. This membership is limited to persons who are actively engaged in the vocation of agriculture. This is the record of the year's accomplishment in organization. Naturally, interest follows in the educational and coöperative results obtained through this organization.

The educational work has been carried on by lectures given by officers of these societies at regular and special meetings. From time to time members of the Bureau of Agriculture and others have delivered lectures to the societies. It is estimated that over 40,000 farmers were reached by the exhibit, demonstration and lectures of the successful "Rice-special" trip this season, a 45-day tour over the lines of the Manila Railway.

Commencing in November, 1914, a market report containing a summary of Manila prices on standard farm products such as rice, copra, abacá (Manila hemp), sugar, tobacco and live stock, has been compiled weekly and a copy has been mailed promptly every week to the president of each provincial and municipal society for the guidance of the members in marketing their farm products. A weekly cable report of New York sugar prices has been received and promptly forwarded by wire to the leading sugar-producing provinces.

In the month of January, 1915, the publication of the Philippine Farmer was commenced, a monthly periodical devoted to practical farm topics. It is printed in English and Spanish and is sent free to every member of the Philippine Agricultural Society.

The writer has personally visited as many of the societies as the limited time at his disposal permitted, and has delivered talks on coöperation and assisted in every way possible in maintaining interest in the organization. Acting Director Hernandez, the chief of the demonstration division of the Bureau of Agriculture and the field men of the Bureau have aided in the educational work by holding special meetings in which educational work in seed selection, soil preparation, methods of planting, irrigation, cultivation, the use of modern implements, preparation and marketing of products, and of the spirit of coöperation and united action, has been carried forward with marked success.

Although the work of these newly-organized societies during the past year has necessarily been largely educational and will probably be of that nature for some time to come, yet the results of agricultural education and even ventures along coöperative lines are apparent. In the Food-production Campaign of last

year, although the societies were in their infancy, they were an important aid in increasing production of secondary food products all over the Islands. The president of the Provincial Agricultural Society of Albay states that although the recent prolonged drought was so severe that in many places 80 per cent of the abacá (Manila hemp) crop was ruined, the price of food products did not advance, due to the excellent work of the agricultural societies in conducting the food-production campaign.

Coöperation was apparent in the Province of Tayabas during the recent campaign against bud-rot in the coconut groves. Meetings of the societies were held, lectures were delivered, and active support was given by the members to the enforcement of the strict measures of the Bureau of Agriculture for the suppression of this destructive disease.

In Pampanga, the provincial society has been very active in laboring for the welfare of the farmers of the province. The officers of the society have held important conferences with the officials of the Manila Railway Company and were successful in securing better train service, equipment, etc., and many times during the last session of the Legislature made known the wishes of Pampanga farmers on important legislative matters.

In Iloilo, the president of the provincial society states that there is a demand for selected seed by farmers from every municipality in the province, a condition heretofore unknown in the history of the province. He attributes this largely to the activities of the agricultural societies and to information obtained by reading the society publication, the Philippine Farmer.

Agricultural inspectors, fiber inspectors and field men of the Bureau generally, report that the societies have been of assistance to them in their field and demonstration work.

In many municipalities the farmers hold their meetings in the home of some member of the society where the farm paper is read regularly and translated into the local dialect, and the topics are discussed and much valuable information is obtained.

In several localities, members of the society have bought live stock, community owned, for the purpose of improving the herds of the members. The animal-husbandry division of the Bureau of Agriculture receives many communications every week along this line.

Members of the society in Tarlac and other provinces have pooled their interests in irrigation projects, the coöperative plan proving very satisfactory.

In several localities coöperative stock corporations have been formed and shares offered to members on the plan of paying for

the same in regular monthly installments, thus adding a savings feature to that of coöperative business. This idea is exemplified fully in the society known as the Lipa Young Farmers' Association, a branch of the Lipa, Batangas, Municipal Agricultural Society. This society, as its name implies, is composed of young farmers. It has a membership of over 40, the shares have a par value of $5 each and each member must own at least one share. The company is organized to deal in improved live stock and conduct a general agricultural business coöperatively.

In the Province of Albay a big two-days special meeting or congress was held during the past year. Addresses were made by the provincial governor, the lieutenant governor, by lawyers, doctors, the third member, the president of the provincial agricultural society, the provincial delegates and many others of prominence.

Another event in which the organized farmers of the Islands played a prominent part was the Farmers Congress held in Manila, August 21 to 28, 1915. This great meeting was called upon the initiative of Honorable Manuel Quezon, resident commissioner, and the members of the Economic League, a Manila organization. Members of the Philippine Agricultural Society were well represented at this meeting and helped in every way possible to make it a success. Nearly 500 delegates attended, representing nearly every province in the Archipelago. Addresses were made by leading officials of the Government, by educators, commercial men, leading farmers, and Bureau specialists. The members of the various committees worked earnestly and intelligently on the difficult tasks assigned them, and the result of their labors as outlined in the 34 resolutions adopted on the last day of the meeting was highly creditable. In the selection of the officers of the congress, the organized farmers were fully recognized, as every officer is a member of the Philippine Agricultural Society. The president of the congress, Mr. Matias Gonzalez, is president of the Provincial Agricultural Society of Pangasinan. The first vice-president, Mr. Gregorio Yulo, is president of the Iloilo provincial society. General Alejandrino, of the Pampanga society, is second vice-president. Mr. August Gonzalez, secretary of the congress, is the secretary of the Pampanga provincial society, and Mr. Carlos Locsin, of the Negros provincial society, is also a secretary of the congress, these two secretaries also acting as treasurers.

The active participation of the Philippine Agricultural Society in the deliberations of the Farmers Congress, and the pronounced success of the congress itself, are matters of congratu-

lation, but the calling of the congress at the particular time it was held seriously interfered with one plan of the Philippine Agricultural Society, that of the organization of an Insular Agricultural Society. The Farmers Congress so carefully covered all Insular matters of an agricultural nature and brought so many of the leading farmers into conference, that it was not deemed expedient to attempt the organization of an Insular Agricultural Society until some later date. When this work is accomplished together with the addition of provincial organizations in the few remaining provinces, the organization will be complete. It is the first effort at organization on so large a scale ever attempted in the Philippines.

The record of accomplishment in one short year speaks for itself. The society is as yet in its infancy but the results obtained are encouraging and prove the wisdom of the adoption of the plan of organization. Success has by no means been attained in every case. Some of the societies that were enthusiastic at the start, have grown indifferent and results in these instances have been negative. It is a constant struggle to keep interest alive, to keep the societies on their feet and moving. There have been discouragements along with the small measure of success attained during the first year of agricultural organization in the Philippines. The fact that some progress has been made is encouraging. There is justification in the belief that through organization, education and coöperation faithfully upheld in the years to come, great improvement will be made in agriculture, for with these three forces properly directed will come increased production, better systems of marketing, lower interest rates and more extended irrigation systems, increased revenues for schools and transportation, more comforts, and less grinding toil, relief from present isolation, more self-reliance, a new viewpoint of the dignity of farming as a vocation, happy homes and a prosperous and contented people. The attainment of these conditions could hardly be expected in one year of organization, education and coöperation. But a start has been made. The way has been opened. It leads straight to prosperity. The ultimate success necessarily rests with the farmers themselves. If they become indifferent, their condition can hardly be expected to improve. If they continue to show a willingness to progress as they have done in a majority of the provinces during the past year, the road to success is plain.

BOOK REVIEW.

By CLEVE. W. HINES, M. S., *Station Superintendent.*

PRACTICAL WHITE-SUGAR MANUFACTURE.

One of the latest books on the subject of sugar to reach this Bureau bears the above title. It is from the pen of the eminent sugar technologist, Dr. H. C. Princen Geerligs.

There is a growing interest in the production of high-grade sugars directly in the plantation factory, which eliminates the expensive boneblack process of the refiners, thus placing the sugar planter and manufacturer in a more independent position.

There are a number of well-established methods in use for this work, and each year brings forth numerous other methods, many of which contain advanced ideas worthy of consideration. This new book briefly summarizes the better systems now in use, and passes comment on the good and bad points in each.

The book is divided into three parts, the first of which deals with cane-juice clarification, treating respectively of the principles of clarification, defecation, carbonitation methods, special methods, and the advantages of the different clarification processes. Part two deals with boiling, curing and storing of white sugar, while part three treats of the different materials employed in the manufacture of plantation white sugar.

This book may well be considered as the most authentic treatise now extant on the subject of white-sugar manufacture, and will be welcomed by sugar planters throughout the world.

It may be obtained from Norman Roger, 2, St. Dunstan's Hill, England, price 12 shillings.

CURRENT NOTES—THIRD QUARTER.

NOTES BY P. J. WESTER, Horticulturist in Charge of Lamao Experiment Station.

NOTES FROM HAWAII.

Fruit analyses.—The annual report of the Hawaiian agricultural experiment station for 1914 contains much information of interest. One of its most valuable contributions is an article on the "Composition of Hawaiian Fruits and Nuts," by Alice R. Thompson.

Miss Thompson gives the analyses of 47 species of fruits and nuts, and of several varieties of avocados, mangos, bananas, and papayas. As is well known, the fat content in the avocado varies greatly in the fruit from different trees, averaging from 12 to 16 per cent of the entire fruit. One of the avocados analyzed gave the remarkably high fat content of 21.79 per cent.

With the recent discovery of a practical method of propagating the seedless breadfruit on a large scale, the analysis of this valuable fruit assumes particular interest to those living in the Tropics, as the bread-fruit is one of those fruit trees that is already paramount in the sustenance of the population in some of the archipelagos in the Pacific Ocean, and has remarkable climatological adaptability. That it is so little used in most of the Torrid Zone is due partly to ignorance of its virtues and partly to the difficulty of its propagation herefore. With both these obstacles removed we may in the future expect to see large areas devoted to breadfruit culture throughout the Tropics, particularly with the dissemination of the reputedly superior varieties from the Marquesas Islands, which are said to have more than two score different kinds.

In the analysis made in Hawaii the breadfruit was found to have a considerably higher food value than the banana, with considerably less waste. The edible portion in the banana varied from 64.29 to 75.72 per cent, while in the breadfruit from 77.75 to 83.44 per cent. The protein and fat content averaged about the same in both fruits, while the total sugar in the breadfruit ranged from 9.49 to 14.60 per cent, in the banana varying from

14.49 to 26.20 per cent. The starch in the banana was at most 2.57 per cent against 9.27 to 27.89 per cent in the breadfruit.

Rubber.—Last year the writer suggested in this periodical [1] that the time would come when rubber plants would be propagated asexually, as a result of selection and breading. It appears from the above report that this suggestion was anticipated by two years by Mr. W. A. Anderson, superintendent of the rubber substation at Nahiku, Maui, Hawaii, and his is in all probability the first attempt to vegetatively propagate a rubber plant with the definite object in view of increasing the yield of rubber. The cuttings were made in 1912 from selected Ceara rubber trees and tappings were made from the resultant trees in 1914 with indications that "this method of propagation can be successfully employed to transmit desirable latex-yielding properties."

Roselle.—The roselle crop of Maui (one of the Hawaiian islands) in 1914 was valued at ₱105,600, grown on 88 hectares—a gross return of ₱1,200 per hectare—the roselle being grown chiefly as a secondary crop between the rubber, and the calyces dried and exported. The following is quoted verbatim from the report, the measurements having been reduced to the metric system:

> The rubber trees among which the roselle was planted were spaced 3 to 6 meters. The roselle was accordingly planted 1.5 by 1.5 meters as the most convenient spacing to utilize the soil in conjunction with the trees. This is rather close planting where the bushes grow as large as in the Nahiku district. In the early plantings on the lower elevations the plants grew to a height of 2.4 to 3 meters bearing the fruit rather too high for convenient picking. These plants yielded, however, at the rate of 4.5 kg. per plant, or roughly, 16,800 kg. per hectare among the rubber trees. With the same yield per plant, and the rubber plants replaced by roselle we should have had over 19,000 kg. per hectare, which is a larger yield than has been elsewhere reported.

This extraordinary yield was grown with a rainfall of 2,729 mm., probably fairly equally distributed throughout the year.

Since roselle has been found profitable in Hawaii with labor at not less than ₱2.00 per day, it would seem that it should also be profitable in the Philippines where labor averages, at most, 75 centavos per day.

Mesquit meal.—The use of mesquit meal, the ground pods of the mesquit, *Prosopis juliflora,* or algaroba, as it is called in Hawaii, for stock feed is rapidly increasing throughout the Hawaiian Islands, the annual consumption now being valued at

[1] "Opportunities in Plant Improvement in The Tropics." See this REVIEW, Vol. VII (1914), No. 3, p. 123.

₱700,000. This plant, introduced into Hawaii ninety years ago, grows largely on waste land, and does not occupy any of the agricultural land. The tree is of rapid growth, a very valuable source of honey, and makes good firewood. Thousands of hectares of unoccupied land in the Philippines could probably to great advantage be planted to this tree.

Papaya.—Considering the ease with which the papaya can be grown in the Philippines, the statement in the report that papain can be produced at a profit of ₱5 per pound (0.45 kg.) should be of great interest to the Philippine agriculturist. The experiments in Hawaii indicate that papain to the value of ₱4 can be obtained annually from one papaya plant. "It has been found that the papain is injured if the juice is allowed to come in contact with any metallic substance. The only precautions to be observed are that tapping be done with a glass, bone or ivory instrument, and that the juice be collected in china or earthenware containers and promptly dried."

SUBSTITUTES FOR LEMONADE.

Always appreciated in a warm climate, lemonade or limeade or similar drinks from other citrus fruits are not everywhere obtainable, but good substitutes may be produced from the fruits of certain other trees and plants. Quite accidentally the writer found recently that an excellent beverage, which we may call mangoade, can be made from inmature mangos, and that it is quite equal to lemonade in its refreshing qualities, though of course differing in flavor. Mangoade is prepared thus: peel, slice and rinse unripe mangos, and boil in enough water to cover the fruit; strain the mass through a fine cloth and cool; when serving, add sugar and water to taste.

By planting seed from time to time throughout the year, roselleade may be had at a very slight expense at all times of the year.

Roselleade is made as follows: Cut the leaves and tender stems, rinse, and put in a kettle with enough water to cover the herbage after it is wilted, bring to a boil, strain and cool. Serve as mangoade.

In both cases great care should be taken to boil and keep the liquids in earthen, granite enameled ware or glass in order to avoid poisoning caused by the contact of the strong fruit acids with metals.

Ripe tamarinds may be made into a delicious cooling drink that is unsurpassed in flavor, and also they make unusually

well-flavored jelly. The iba, *Cicca disticha*, may also be utilized in making what may be called "ibaäde" of very good flavor, and doubtless, the camia, *Averrhoa bilimbi*, and other acid fruits could be employed in a similar way.

CALAMONDIN OR KUMQUAT?

Three years ago the Bureau of Agriculture imported from Australia budwood of what purported to be the kumquat, *Citrus japonica*. The resultant plants made good growth and one plant has already yielded two crops of fruit, and this year bloomed heavily for the third time. When the first fruits ripened the writer was struck by the similarity of the fruit of the alleged kumquat and the native calamondin, *Citrus mitis*, and therefore made careful comparisons between all parts of the two plants, including the flowers, with the result that the two were found to be indentical in every respect.

The "sour" kumquat, described by Hume in "Citrus Fruits and Their Culture," is also in all probability the calamondin parading under another name.

THE SEEDLESS MABOLO, A NEW FRUIT FOR THE TROPICS.

Among the less well-known tropical fruits that are commonly propagated from seed, the mabolo is the first species to permanently contribute to tropical pomology a seedless fruit of greatly improved quality. The writer had for more than three years heard of the existence of seedless mabolos, but largely for the reason that nothing was known as to whether or not the mabolo could be propagated vegetatively the matter was left in abeyance. During the past dry season experiments were made at Lamao that yielded very satisfactory results and it was found that the mabolo is readily shield budded. (See Current Notes in the preceding issue of this Review.)

For a description of the mabolo as ordinarily found in the market consult the preceding issue of this Review. The ordinary mabolo is of rather poor quality, and notwithstanding its size and attractive appearance it has never gained the favor of the European. The seedless fruit is oblate, sweet and juicy, and of good flavor, absolutely coreless and without seed. In other words, as in the banana, the entire fruit is edible, the thin skin excepted, and altogether it is a very superior fruit that is sure to gain popularity. According to the owner of the trees 80 per cent of the fruit is seedless, the remainder containing from one to three seeds.

VEGETATIVE PROPAGATION OF TROPICAL FRUITS.[1]

Experiments in vegetative propagation of tropical fruits have been continued at the Lamao experiment station, as a result of which "propagation recipes" are given relative to the following species:

Barbados cherry, *Malpighia glabra.* Use petioled, light gray to greenish, mature budwood; cut the buds 3.5 centimeters long; age of stock at the point of insertion of the bud unimportant.

Casimiroa, *Casimiroa edulis.* Use petioled, fairly mature, greenish budwood; cut the buds 3.5 centimeters long; age of stock at the point of insertion of the bud unimportant.

Catmon, *Dillenia philippinensis.* Use fairly mature, dark green or purplish, smooth, petioled budwood; cut the buds 3 centimeters long; age of stock at the point of insertion of the bud unimportant.

Duhat, *Eugenia jambolana.* Use barely mature, green or reddish, smooth, petioled budwood; cut the buds 4 to 4.5 centimeters long; age of stock at the point of insertion of the bud unimportant.

Genipap, *Genipa americana.* Use mature, bluish-green, smooth, non-petioled budwood; cut the buds 4 to 4.5 centimeters long; age of stock at the point of insertion of the bud unimportant.

Jujube, *Zizyphus jujuba.* Use mature, grayish, tomentose, petioled budwood; cut the buds 3.5 to 4 centimeters long; age of stock at the point of insertion of the bud unimportant.

Ketembilla, *Aberia gardneri.* Use petioled, preferably spineless, not too old budwood with tomentum still present; cut the buds 3 to 3.5 centimeters long; age of stock at the point of insertion of the bud unimportant.

Nelli, *Phyllanthus emblica.* Use mature, greenish brown, petioled budwood; cut the buds 3.5 centimeters long; age of stock at the point of insertion of the bud unimportant.

Phalsa, *Grewia asiatica.* Use mature, brownish, petioled, tomentose budwood; cut the buds 3.5 centimeters long; age of stock at the point of insertion of the bud unimportant.

The Muscadine grape, *Vitis rotundifolia,* including the Scuppernong, Labama, Mish, James, Thomas and several other varieties, in southern United States is usually propagated by means of layering, but it has been found that hardwood cuttings inserted in sandy soil under half shade during the dormant season take root easily. Make the cuttings about 25 to 30 centimeters

[1] See also this REVIEW, Vol. VIII (1915), No. 2, page 135.

long, with two to three buds, and insert ⅔ to ¾ of the cutting in the soil so that one bud is just above the soil. Pack the soil well around the cuttings.

Lanzone, *Lansium domesticum.* This species has proved to be one of the most difficult subjects that the writer has handled, and the results obtained after a year's work are still far from satisfactory. Shield budding in all its modifications has given very poor results; cleft grafting has been more successful and should give 40 to 60 per cent of growing grafts. The scion should be made of well-matured growths not too old and hard, 6 to 8 centimeters long and 7 to 10 millimeters in diameter, and should be inserted in the stock 6 to 10 centimeters above the ground, when at that height the stock is 7 to 15 millimeters in diameter. After tying the graft, carefully cover all wounds with grafting wax. Like cacao the lanzone is difficult to transplant and it is best to rear the seedling plants in bamboo tubes for transplanting to the orchard and to perform the grafting operation there, not in the nursery.

Mangosteen, *Garcinia mangostana.* Like most other tropical fruits the mangosteen is propagated from seed. It is of course self-evident that the propagation of seedless varieties or the extension of the mangosteen season cannot be accomplished until the mangosteen can be propagated asexually. However, the mangosteen is of such exceedingly slow growth that it will probably never be chosen as a stock until all other possibities have been exhausted.

Generally speaking, the requirements for successful grafting or budding are about the same in related plants, and in order to ascertain the ease with which *guttiferous* plants might be shield budded a series of buds were inserted on the Palo Maria, *Calophyllum inophyllum.* These buds, about one half of which were petioled, all made good unions and sprouted without difficulty, which indicated that related plants would likely be "easy" subjects. A few plants of the guta-gamba, *Garcinia venulosa,* were on hand and these were also budded, and a dozen buds of this species (*Garcinia venulosa*) were also inserted in *Calophyllum inophyllum* stock. All the buds took and made perfect unions. Well-matured but green and smooth, nonpetioled mangosteen budwood was then procured and buds inserted both on *Garcinia venulosa* and *Calophyllum inophyllum.* Good unions resulted in most instances. Four months after the insertion of the buds nearly all the buds of *Garcinia venulosa* and 50 per cent of the mangosteen buds were still alive, but had not sprouted and are gradually being callused over.

The result of this experiment indicates that the budding of the mangosteen is easily accomplished and that the real problem is the discovery of a congenial, vigorous stock.

The mammee, *Mammea americana*, a guttiferous fruit of tropical America has very good shipping qualities and is of considerable variation, some trees bearing fruit of excellent quality. If, as is probable, this species can also be readily shield budded, there is a possibility that the mammee before long will go through the same experience as the avocado, which was all but unknown until about 15 years ago when it was found in Florida that it could be budded. Following the advent of asexual propagation, large numbers of varieties of avocado have now sprung into existence and its cultivation is rapidly spreading. Considering the short time since the culture of the avocado was placed on a scientific basis, large areas have been planted to this fruit in Florida, California, Cuba and Porto Rico.

It has recently been noted that, as with several other plants, severed roots of the carambola, *Averrhoa carambola* and bael, *Aegle marmelos*, are able to develop germinative tissue and establish themselves as independent plants.

NOTES ON SUGAR, BY CLEVE. W. HINES, M. S., Station Superintendent.

INCREASED DEMAND FOR PHILIPPINE SUGAR CAUSED BY THE WAR.

There has been an increased demand for Philippine sugar occasioned by the recent war and this demand will be felt for a long time after the war has finished. Under normal conditions it is difficult to dispose of any but the very highest grade of molasses sugars in the United States, and these are taken only to fill the gap between the crops of centrifugal sugars, or in a time of scarcity of sugars as in the present case.

The centrifugal sugar made in these Islands, however, is always in demand and is usually transported directly from the wharf of the central to the refinery, which eliminates the paying of storage and agents' profits.

NOTED SUGAR TECHNOLOGIST ACCEPTS POSITION AS MANAGER OF LARGE CUBAN SUGAR PLANTATION.

Mr. Noel Deerr, the sugar technologist who was for many years connected with the Hawaiian Sugar Planters' Association, resigned his position to take up extensive research in the sugar industry for the Cuban Government. He has since resigned that position to accept an appointment as Superintendent of the Jobato Sugar Estate in Oriental Cuba.

INSTRUCTIVE PAPER ON SUGAR DETERIORATION.

Prof. W. L. Owen read a very able paper before the Louisiana Sugar Planters' Association at their March meeting, on the subject "Some Factors Influencing Sugar Deterioration." He stated that scientific investigations had shown that sterile sugars do not deteriorate and that in order to preserve these sugars for an indefinite period of time it is only necessary to properly enclose and store them in a suitable dry place.

SUGAR CROP OF LOUISIANA.

The sugar crop of Louisiana for the year 1914 amounted to 242,700 short tons, which was nearly 50,000 tons less than the previous crop. This shortage was caused by the smaller acreage occasioned by the reduction of tariff on sugars. It is interesting to note that about one-half of the output for the past year was made in the form of a high-grade sugar for direct consumption. There were 149 factories in operation the past year as against 153 during the previous year.

MICROÖRGANISMS IN CANE JUICE.

A very interesting article from the eminent sugar technologist, Dr. H. C. Princen Geerligs, appeared in the February number of the Louisiana Planter, entitled, "Action of Micro-Organisms in Cane Juices and Syrups." He states that one of the most troublesome organisms in cane juices, once it gets started, is the *Lenconnostoc misenterioides* which gives rise to the gelatinous substance called "dextran." This organism finds more favorable condition for growth when the juice is in an alkaline state.

WORLD'S SUGAR PRODUCTION.

The world's production of sugar for the years 1912–13, 1913–14 and estimated by Willett Gray for 1914–15, is as follows:

	1914–15	1913–14	1912–13
Total cane sugar	9,588,096	9,802,248	9,232,543
Total beet sugar	7,901,759	8,850,470	8,976,271
Grand total	17,489,855	18,652,718	18,208,814

SUGAR-BEET SEED PRODUCED IN THE UNITED STATES.

On account of the European war there will probably be very little sugar-beet seed sent out of Germany and Austria for a long time to come and consequently the United States must look for a new source of supply.

A valuable article appears in the May number of "Sugar" by Dr. Frank S. Harris, agronomist, Utah Agricultural Experiment Station, who has done extensive work in this line. He states that sugar-beet seed can be readily produced in certain sections of the United States and that there are great prospects for this new industry in the West where a considerable area will be planted in the State of Utah the present year.

NOTE BY DR. W. H. BOYNTON, Veterinary Pathologist.

SINGAMUS LARYNGEUS.

In the American Journal of Veterinary Medicine for June, 1915, there appeared a note on "*Syngamus laryngeus* from Cattle in the Philippine Islands" which will be of special interest to students of parasites of domestic animals. This note was written by Dr. Maurice C. Hall, Assistant Zoölogist of the United States Bureau of Animal Industry, Washington, D. C., and is as follows:

In a collection of parasites furnished to the United States Bureau of Animal Industry through the courtesy of Dr. William H. Boynton of the Philippine Bureau of Agriculture, there were a number of specimens of *Syngamus laryngeus* Railliet, 1899, collected in the vicinity of Manila. Some of the specimens were loose in a bottle and others were attached to the laryngeal mucosa in the region at the base of the epiglottis in a larynx from a cow. They also occur in the carabao.

The species was described by Railliet from material sent him from Nha-Trang, Annam, where it was found in over half of a hundred cows examined postmortem in connection with a study of rinderpest. In this connection it may be noted that the bovine specimen furnished by Dr. Boynton also shows lesions of rinderpest. The record of this parasite given by Railliet has been quoted by a number of other writers, such as Neuveu-Lemaire, Fiebiger, and Hutyra and Marek, but I have not found any additional records.

An examination of the Philippine material shows it to be identical with that described by Railliet. The males average a little shorter, measuring 2.75 to 3.1 millimeters, where Railliet's specimens measured 3 to 3.75 millimeters, and the females with which these males are coupled are a little longer, measuring 9.7 to 12 millimeters, where Railliet's specimens measured 8.75 to 9.8 millimeters. The worm shows the transverse striation of the cuticle, and the strong buccal capsule with eight teeth at the base of eight chitinous ribs extending from the base to the mouth aperture.

A very interesting thing in connection with these worms was the finding of one pair of which the male was attached to the vulva of the female in the usual way and also attached to the neck of the female by the buccal capsule. In another case, the male of one couple was attached by means of the buccal capsule to a point opposite the vulva of a female belonging to another couple. In both of these cases the powerful suction had drawn the cuticle of the female deep into the capsule, but not quite in contact with the teeth at the base. With the cuticle, and still protected by it,

were parts of the viscera of the attacked female, including a piece of the ovary in the case of the female attacked by the male of another couple.

In the writer's experience such occurences are rare. However, I am told by Dr. Albert Hassall that the attachment of one trematode to another is not uncommon, and that Rudolphi has made one trematode species which subsequent examination of the type material has shown to be based on a specimen showing a protuberance which was evidently due to a previous attachment of another fluke. The protuberance, which formed a distinguishing character of Rudolphi's species, represented the part of the attacked fluke which had been drawn into the sucker cavity. Grassi and Parona (1879) have reported a case in which two specimens of *Dochmius balsami* (*Ancylostoma caninum*) were found attached to a specimen of *Taenia crassicollis* in a cat.

Railliet states that the worms apparently gave rise to no pathological conditions, except for the immediate local attachment, of course, and there is no record of any correlated pathological effects in connection with the infestation with this worm in the Philippines.

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ERRATA.

In Vol. VIII, No. 2, of this REVIEW, the following corrections should be made:

Page 71, line 37, "cautemoya" should read "cuatemoya;" page 111, third line from the bottom, "325 millimeters;" should read "3.25 millimeters;" same page, fifth line from bottom, "45 to 75 centimeters" should read "4.5 to 7.5 centimeters;" same page, nineteenth line from bottom, "well-known" should read "well-grown."

STATISTICS ON PRINCIPAL CROPS OF THE PHILIPPINE ISLANDS FOR THE YEAR ENDING JUNE 30, 1914.

(Compiled from the official reports submitted by the executive officers of 1 city, 743 municipalities, 84 townships, 25 rancherias, and 8 settlements.)

By ANTONIO PEÑA, *Superintendent of Statistics.*

Crops.	Area cultivated.	Products.	Amount produced.	Average price in municipal markets.	Value of coconut and sugar-cane products in municipal markets.	Total value in municipal markets.
	Hectares.					
Rice	1,244,937	Rough rice	1,705,261,050 liters	₱0.03358		₱57,261,760.19
Abaca	437,470	Abaca (Manila hemp)	137,635,558 kilos	.21773		29,968,009.23
Sugar cane	169,436	Crude sugar	346,429,556 kilos	.0752	₱26,035,568.35	
		Panochas (small cakes)	24,013,110 kilos	.0719	1,726,761.76	
		Basi (a beverage)	9,342,514 liters	.0731	682,668.51	
		Molasses	2,480,029 liters	.0752	186,546.10	
		Total value of all sugar-cane products				28,631,544.72
Coconuts (average of 200 trees per hectare).	245,952	Ripe nuts as food	63,057,700 nuts	.03997	2,520,160.66	
		Copra	107,382,931 kilos	.1618	17,385,087.79	
		Coconut oil	3,595,332 liters	.3408	1,225,412.86	
		Tuba (a beverage)	54,048,393 liters	.0651	3,521,102.72	
		Total value of all coconut products				24,651,764.03
Corn	421,309	Shelled corn	469,961,119 liters	.03378		15,873,804.27
Tobacco	60,890	Leaf tobacco	46,731,463 kilos	.1521		7,109,367.34
Maguey	18,218	Maguey (cantala)	7,583,802 kilos	.1135		860,754.41
Cacao (estimated)	1,168	Cacao	565,802 kilos	.6257		354,057.21
Coffee (estimated)	788	Coffee	626,408 kilos	.4833		302,770.60
Total	2,600,168					165,013,832.00

Equivalents.—1 hectare equals 2.471 acres. 1 kilo equals 2.20462 avoirdupois pounds. 1 liter equals 0.908077 dry quart or 1.0567 liquid quarts. ₱1 (Philippine currency) equals $0.50 (United States currency).

NOTE.—The total area of the Philippines, including all 3,141 islands, islets and reefs, has been reported by the Manila Observatory to be 119,542 square miles, which is equivalent to 309,615 square kilomters, or 30,961,500 hectares.

The area under cultivation in the six principal crops and three of the minor crops, as shown in the above table, is only 2,600,168 hectares. This is 8.4 per cent or about one-twelfth of the whole area of the Islands including mountains and arid lands.

The area under cultivation in fruit trees, bananas, camotes, ubi, gabe, and other vegetables is not included in the above table for the reason that complete statistics on these crops are not available.



A portion of the testing fields showing the rows planted with seeds from selected mother plants. Preliminary feature of pedigree work.

RICE NUMBER

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EDITORIAL.

THE PUBLIC AND PUBLIC SERVICE IN AGRICULTURE.

The past decade has been marked by the development of a rapidly growing interest on the part of the general public in various lines of agricultural effort. Never before has there been such a world-wide interest in this subject, or in farmers as a class, as that which prevails today.

That there should be a widespread interest in agriculture is most natural when it is considered that by far the greater part of the world's food supply comes from the farms. That this interest should increase as the cost of food increases is also inevitable.

It is highly desirable both in the interests of the farmer and of the consumer of the products of the farm that the general public should have an intelligent understanding of agricultural conditions. Where such an understanding exists there is at least a reasonable probability that the efforts made by the consumer to promote the welfare of the farmer will accomplish the desired results. Where it does not exist there is equal probability of failure.

It is a fact surprising, but none the less true, that agriculture has suffered neglect because of the familiarity of the public with this industry. The tilling of the soil was one of the first arts to be developed, and agriculture being a fundamental and world-wide industry has required the services of a larger proportion of the world's population than any other one line of human effort. As other industries have been developed they have been manned in considerable measure by people drawn from agricultural pursuits. As a result of this situation it is a rare experience to meet a man who does not feel confident that he can successfully operate any agricultural enterprise and give sound advice on the many topics bearing thereon. The same man will scrupulously refrain from advising the doctors, lawyers, clergymen, engineers, bankers, and merchants although none of these persons are engaged in professions or business which involve as many technical features as do the operations involved in the production of a staple crop.

As a matter of fact, during the last two decades agriculture has emerged from a "rule of thumb" art to a profession fairly bristling with science. It is rapidly changing from a "one-man independently-operating" business to a community enterprise. The evolution has been so radical and rapid that the public at large and many of the farmers themselves do not realize what has transpired. Consequently, we have the public on one hand sagely offering the farmers advice with but a superficial knowledge of the subject, based on the assumption that conditions have not and are not changing, and on the other hand a certain class of farmers blindly refusing to accept or acknowledge present-day conditions and attempting to treat their farms as the self-sustaining, self-sufficient, and independent enterprises they were a generation ago.

An unfortunate result of this situation has been the development of a certain amount of antagonism between country and city people. The farmers have a tendency to regard the people of the cities as parasites; whereas the city people are in a measure inclined to look upon the country people as legitimate prey. This condition where it exists is largely due to ignorance, as both classes are mutually dependent each upon the other, and their interests are, in the main, identical.

In the more progressive localities and among the more intelligent people the idea is growing that the community embraces the largest possible unit. The town embraces all the hamlets and farms naturally contiguous to it and the city embraces all of these larger communities naturally contiguous to it.

As a result of the realization of a community interest we find the people who live in cities and towns contributing to the support of different agencies designed to educate the farmer. Two of the most prominent of these agencies are the agricultural agent and the experiment station.

The public, having provided the necessary means for the employment of an agricultural agent, or having contributed to the support of an agricultural experiment station, is always disposed to constitute itself a critic of the work of such agents and stations. Such criticism, when based on an intelligent understanding of the work, may be most helpful, otherwise it may do a great deal of harm.

The agricultural investigator who is engaged in public service has to meet at all times a more or less insistent demand for specific and immediate results. In order to meet this demand, even in a moderate degree, the work of the investigator is

often seriously hampered, and his employer—the public—suffers serious loss.

That which is most urgently needed is confidence on the part of the public in the ability of agricultural specialists employed in public service to properly carry on the work in which they are engaged. The wonderful results that have already been accomplished along many lines of agricultural research have tended to establish the confidence of the public in such work, and as other and more important results are obtained, the agricultural specialist may confidently expect the stronger and more general support of his work by the public.

OBSERVATIONS ON THE INFLUENCE OF AREA PER PLANT ON YIELD OF GRAIN IN RICE CULTURE.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

An important point in lowland rice culture is the proper spacing of hills. Just how far apart may hills be spaced without prejudice to maximum yield of grain? If, on the other hand, close planting is deemed essential to prevent weed growth, how closely may the hills be set?

It has been noted that there is great diversity in practice in these Islands, in so far as spacing of hills is concerned. In some districts very close planting is customary, in others the contrary. The prevalent tendency with all crops is too close planting, and the impression the casual observer retains is that rice is commonly overcrowded in the field.

The habit of planting too closely is wasteful. In the first place, a certain amount of seed is wasted for which there is far greater utility as food. If but a small percentage of each cavan [1] of seed so used is superfluous, the sum total thereof amounts to considerable proportions.

Calculating that one cavan of seed is sufficient to plant a hectare of lowland rice and a cavan and a half to plant a hectare of upland rice, not more than a million and a half cavanes of seed will be required to plant the 1916 crop. But not less than 750,000 cavanes of rice will be planted in addition to the amount actually necessary, which at seed prices is a waste of more than two million pesos, in the first instance, not to mention other wastes that naturally follow the initial one. Among other wastes is that of labor in setting out more hills of plants to the hectare than are necessary. If such close planting interferes with the normal growth of the plants, still another waste occurs, and there are other relative wastes.

[1] One cavan equals 75 liters.

A preliminary investigation was conducted at the Alabang stock farm with the object in view of determining the influence on yield due to differences in spacing of hills.

Three quite widely differing varieties were selected to be planted in this test. One was an early-maturing variety, No. 663, requiring about 145 to 148 days to ripen; a medium-early one, No. 692, maturing in 174 days; and a late-maturing sort, No. 225, ripening in 187 days.

The seed was sown June 15 in seed beds and the seedlings transplanted six weeks later in a set of five duplicate plots, each plot being ten meters in length and of sufficient width to accomodate six rows of plants.

Only one seedling was set in the hill, and in order to equalize the distribution of plant food in the soil, border rows were set on the sides of the plots so that each set was a solid block.

The following table shows the general scheme of handling the plots.

Series No.	Spacing.	Plants per square meter.
	Centimeters.	
I	10×10	100
II	10×15	67.
III	15×20	33
IV	20×20	25
V	25×25	16

During the early period of growth there was no noticeable difference in the general appearance of the several plots in the series, but by the time the plants began to bloom, they were taller, more slender, and somewhat paler in color in series I and II than in the others. The differences in average height of plants between series I and II at heading-out time was 2 centimeters and between series II and III the same. Series IV and V were uniformly similar to series III.

By the time the kernels were in the dough state there was no difference in the heights of the plants of a given variety in the several plots. All plots matured at the same time, so there was no influence on maturing period due to close or sparse spacing of hills.

The following table shows the results obtained:

EXPERIMENT No. 1.

Spacing.	Variety No.	Average— Number of culms per plant.	Height of plants.	Length of panicle.	Number of branches per panicle.	Number of grains per panicle.	Yield of rough rice per square meter.	Yield of straw per square meter.	Number of bearing culms per square meter.	Yield of rough rice per 1,000 culms.
Centimeters.			*Cm.*	*Cm.*			*Kilo.*	*Kilos.*		*Kilos.*
10 × 10	663	3.0	126	24.0	9.5	113	0.439	0.323	300	1.46
	692	2.4	136	22.3	9.8	127	.354	1.26	240	1.47
	225	3.5	157	31.0	9.5	117	.317	1.24	350	.905
10 × 15	663	3.6	128	25.3	10.0	135	.388	.280	239	1.62
	692	3.7	136	22.9	10.6	151	.299	1.11	246	1.22
	225	4.0	158	32.0	10.8	147	.241	1.17	266	.906
15 × 20	663	4.7	129	25.3	9.7	135	.282	.333	157	1.79
	692	4.5	138	22.6	10.5	161	.233	.759	150	1.55
	225	4.4	154	32.3	11.4	155	.187	.910	147	1.27
20 × 20	663	5.2	129	25.3	9.4	139	.197	.347	130	1.52
	692	6.2	139	22.7	10.3	172	.231	.862	154	1.50
	225	5.4	156	31.7	11.4	145	.158	.873	135	1.17
25 × 25	663	6.3	127	25.1	9.5	137	.188	.383	101	1.86
	692	5.7	138	23.0	10.6	154	.172	.427	91	1.89
	225	5.7	151	31.9	12.4	168	.148	.689	91	1.62

As the area per plant was enlarged the number of culms per plant increased, though less marked in the tallest and latest-maturing variety.

The variation in space per plant apparently had little effect on the height. The length of the panicle was not affected.

The number of branches per panicle remained stable in both the earlier varieties but gradually increased in number on the late-maturing one as the area per plant was enlarged.

With all varieties the number of grains per panicle was less when only 100 square centimeters was allotted each plant, but when the area was increased to 150 square centimeters or more per plant the average number was but little affected. The other variations recorded with regard to number of grains are deemed to be too slight to be considered.

The yield of grain dropped according to the space allowed plants, indicating that not more than 100 square centimeters per plant should be allowed in order to secure maximum yields, but that a lesser area would suffice. It is regretable that the series were not planned to include closer spacing.

An explanation for the high yield on the closely planted plots is found in the greater number of bearing culms per square meter. This condition offsets any increase due to a greater number of culms per plant, and a greater number of grains per panicle. None of the varieties was capable of stooling sufficiently to provide as many culms as the soil could support.

The yield of straw was but slightly influenced by difference in spacing in the earliest-maturing variety, but it fell off rapidly with the other two as the area per plant was enlarged.

Another preliminary test was made with reference to the effect of various numbers of seedlings per hill, using the same varieties as in the test discussed above.

In this investigation all hills were spaced 25 centimeters apart both ways, and one, two, three and four seedlings placed in each hill. Unfortunately, all but one set were washed away by a flood of water. This was variety No. 663.

The results of this test are recorded as follows:

Number of plants per hill.	Average—				
	Number of culms per hill at harvest.	Height of plants.	Length of panicle.	Number of grains per panicle.	Yield per square meter.
		Cm.	*Cm.*		*Kilo.*
1	8.9	144	26.1	141	0.271
2	9.3	143	25.9	142	.250
3	9.6	140	24.6	139	.286
4	9.8	138	24.8	124	.263

Reference to the tabulation of "Experiment No. 1" shows that No. 663 did not tiller as fully in that test as in the one shown just above, the rate being 6.3 culms to the plant as compared with 8.9. It is not possible to account for this difference by referring to the data on hand. The seedlings for all the plots planted with No. 663, in all the work considered so far, were taken from the same seedbed and planted on the same date. The soil was very uniform in all respects. The average maintained by this variety in plot tests is 6.2 culms per plant, consequently the results obtained with reference to yield were evidently affected by other influences than those under consideration.

Since the preliminary test with reference to the effects of space per plant on yield had led to such positive results, a much more extensive experiment was planned for the succeeding season.

The same varieties were used and the seedbeds sown June 26, the plots planted July 23 to 26, inclusive.

Five sets of duplicate plots were laid out to be planted with 1, 2, 3 and 4 seedlings per hill, and the hills to be spaced 10 by 10 centimeters; 10 by 15 centimeters; 15 by 15 centimeters; 15 by 20 centimeters and 20 by 20 centimeters. This arrangement provided for 100, 150, 225, 300 and 400 square centimeters per hill and with the planting of 1, 2, 3 and 4 seedlings per hill, the subdivision of each area was made accordingly.

In order to make comparisons with the first season's results, the plots with single seedlings will be treated first.

EXPERIMENT No. 2—*One seedling to the hill.*

Spacing.	Variety No.	Average—				
		Number of culms per plant.	Number of grains per panicle.	Yield of rough rice per square meter.	Number of bearing culms per square meter.	Yield of rough rice per 1,000 culms.
Centimeters.				*Kilo.*		*Kilos.*
10 × 10	663	3.4	98	0.185	340	0.544
	692	2.4	137	.129	240	.537
	225	2.7	160	.163	270	.603
10 × 15	663	3.8	100	.159	253	.628
	692	2.8	147	.140	186	.753
	225	3.2	175	.185	213	.869
15 × 15	663	4.9	114	.148	217	.682
	692	2.5	155	.156	111	1.40
	225	3.1	167	.113	138	.819
15 × 20	663	5.4	98	.161	171	.941
	692	4.2	110	.119	140	.850
	225	3.3	146	.177	110	1.61
20 × 20	663	5.7	132	.161	142	1.13
	692	4.1	144	.141	102	1.38
	225	4.2	157	.125	105	1.19

EXPERIMENT No. 3—*One seedling to the hill.*

Spacing.	Variety No.	Average—				
		Number of culms per plant.	Number of grains per panicle.	Yield of rough rice per square meter.	Number of bearing culms per square meter.	Yield of rough rice per 1,000 culms.
Centimeters.				*Kilo.*		*Kilos.*
10 × 10	791	4.8	----------	0.333	480	0.695
	97	4.2	118	.417	420	.993
	426	6.4	113	----------	640	----------
10 × 15	791	6.4	----------	.329	426	.772
	97	5.2	120	.403	346	1.16
	426	8.2	151	----------	546	----------
15 × 15	791	12.6	----------	.277	559	.495
	97	6.2	117	.303	275	1.10
	426	9.6	178	----------	426	----------
15 × 20	791	11.2	----------	.280	373	.751
	97	6.8	142	.264	226	1.17
	426	10.6	158	----------	353	----------
20 × 20	791	11.2	----------	.244	280	.871
	97	6.8	----------	.214	170	1.43
	426	7.8	195	----------	195	----------

Variety No. 692 does not attain its average tillering rate which is 6.5 in the variety plot test records, neither does No. 225 which has an average tillering record of 6.0 in the variety plot tests. Sometime ago the writer adopted the unit of 34 square centi-

meters per culm as a useful standard for population basis, and it will be noted that where the number of culms closely approaches this proportion, or about 330 culms to the square meter, is also found the maximum yield.

When the number of culms falls below this figure, even if more grains are found on the panicle and though the number of culms in the stool is larger, the yield tends to fall off as the square area per plant increases.

The tillering habit is rather elastic although it is quite apparent that the maximum limit is well defined and additional space per plant does not induce tillering beyond a certain definite point.

The number of kernels per panicle is usually regarded as a stable character but as a matter of fact this habit is affected by environment and the degree of stooling which has occured. The average number of grains per panicle of variety No. 665, according to records, is 142, which average number is closely approached except in the closest planting.

The data submitted for Experiment No. 2 are not regular, and there are indications that other influences than those of spacing are in part responsible for the variations from the expected results. This assumption is supported by the fact that the effects of insect attacks and short water supply had to be considered in part. However, the progression of figures is such that one can make deductions. An unknown factor is the weight per 1,000 grains, which if known would explain certain discrepancies.

In Experiment No. 3, several figures are omitted because of doubtful value. The data remaining exhibit a similar manner of progression as noted in the preceding table. One exception should be noted. The number of culms per square meter is unsually large, which fact was accredited to the very favorable growth conditions prevailing during the early part of the season, shortly after transplanting.

Altogether, the most logical deduction which can be drawn from the preceding data is that single seedlings will usually not produce maximum yields if given more space than 100 square centimeters, and that the maximum limit to number of grains per panicle, tillering habit, or possible increase of grain size, is definite and fixed so that, beyond certain restricted limits, these characteristics are not sufficiently elastic to be relied upon to compensate fully for sparseness of plant population per square meter.

In order to get further information the same scheme of spacing as used in Experiments Nos. 2 and 3 was employed, and two and four seedlings were placed in each hill.

EXPERIMENT No. 4.—*Two seedlings to the hill.*

Spacing.	Average—				
	Variety No.	Number of culms per hill.	Number of grains per panicle.	Yield of rough rice per square meter.	Number of bearing culms per square meter.
Centimeters.				*Kilo.*	
10 × 10	663	3.5	82	0.161	350
	692	2.3	117	.111	230
	225	2.8	142	.161	280
10 × 15	663	3.8	73	.201	253
	692	2.6	187	.153	173
	225	3.5	156	.163	233
15 × 15	663	4.4	118	.181	195
	692	4.1	121	.125	182
	225	3.3	149	.129	146
15 × 20	663	5.6	113	.184	186
	692	3.4	126	.133	113
	225	3.8	141	.185	126
20 × 20	663	5.7	138	.177	142
	692	4.4	179	.171	110
	225	4.4	142	.109	110

EXPERIMENT No. 5.—*Two seedlings to the hill.*

Spacing.	Average—				
	Variety No.	Number of culms per hill.	Number of grains per panicle.	Yield of rough rice per square meter.	Number of bearing culms per square meter.
Centimeters.				*Kilo.*	
10 × 10	791	6.6	----------	0.256	660
	97	4.0	129	.383	400
	426	5.0	150	----------	500
10 × 15	791	9.4	----------	.463	626
	97	4.2	135	.381	280
	426	4.8	200	----------	320
15 × 15	791	10.3	----------	.333	577
	97	6.0	134	.429	266
	426	5.4	154	----------	240
15 × 20	791	13.0	----------	.103	433
	97	7.8	131	.281	260
	426	11.0	160	----------	366
20 × 20	791	13.6	----------	.262	340
	97	10.2	106	.210	255
	426	11.4	166	----------	285

EXPERIMENT No. 6.—*Four seedlings to the hill.*

Spacing.	Variety No.	Average.			
		Number of culms per hill.	Number of grains per panicle.	Yield of rough rice per square meter.	Number of bearing culms per square meter.
Centimeters.				*Kilo.*	
10 × 10	663	4.2	76	0.204	420
	692	3.6	118	.129	360
	225	3.1	134	.168	310
10 × 15	663	4.3	93	.197	286
	692	4.3	135	.172	286
	225	3.8	133	.181	253
15 × 15	663	5.5	74	.189	244
	692	3.9	101	.116	173
	225	3.2	135	.141	142
15 × 20	663	5.4	110	.183	180
	692	4.2	149	.127	140
	225	3.8	137	.120	126
20 × 20	663	6.7	105	.198	167
	692	5.3	183	.166	132
	225	5.4	188	.131	135

EXPERIMENT No. 7.—*Four seedlings to the hill.*

Spacing.	Variety No.	Average.			
		Number of culms per hill.	Number of grains per panicle.	Yield of rough rice per square meter.	Number of bearing culms per square meter.
Centimeters.				*Kilo.*	
10 × 10	791	7.4	----------	0.317	740
	97	4.4	125	.430	440
	426	2.8	148	----------	280
10 × 15	791	9.4	----------	.362	726
	97	6.0	124	.416	400
	426	3.8	144	----------	253
15 × 15	791	16.8	----------	.480	746
	97	6.0	130	.362	266
	426	7.4	149	----------	328
15 × 20	791	16.8	----------	.315	559
	97	11.0	141	.273	366
	426	12.4	144	----------	413
20 × 20	791	18.4	----------	.245	460
	97	7.0	134	.214	175
	426	10.0	140	----------	250

The introduction of more than one seedling in the hill tends to produce less regularity in the results. This is especially true with regard to the stooling of the plants, since there will be considerable variation due to the competition between the seedlings in each hill. If a hill has four equally vigorous seedlings it is to be expected that there will be a maximum number of culms per hill while if there is a great difference in the vitality of the seedlings, the weaker ones will compete at a disadvantage and will produce but few culms.

Experiments Nos. 4 to 7, inclusive, tend to show that when the loss due to death of a certain percentage of seedlings, which always operates against maximum production when only one seedling is used, is offset by planting more than one seedling in the hill, the limit to close spacing is reached in spacing hills 10 by 10 centimeters, and overcrowding results. Consequently, the greatest yields are found in the somewhat less densely planted areas. In Experiment No. 6, No. 663 shows but slight influence due to spacing but the other varieties appear to be more vitally affected.

From a practical standpoint, the gain accruing from the practice of setting out single seedlings in the hill would have to be considerable to offset the extra expense incurred in planting the field according to such a scheme. Nor is it possible to attempt to plant an exact number of seedlings in the hill. In practice it will be found that, if three seedlings to the hills is the average sought, the range will be from one or two to five or six.

Too close planting hinders economical and efficient weeding work, and may result in damage being done to the growing plants. A distance of 20 centimeters between hills appears to be quite small enough to permit the passage of the average laborer doing the weeding and yet provide for the safety of the rice plants.

Taking a general average of the results obtained does not reveal any striking feature.

Thus, one plant per hill, spaced 10 by 10 centimeters, 10 by 15 centimeters, 15 by 15 centimeters, 15 by 20 centimeters, and 20 by 20 centimeters, produced an average return of 0.151 kilo per square meter; two plants per hill, 0.154 kilo; three plants per hill, 0.159 kilo; and four plants per hill 0.161 kilo. The variation in yield per hectare is too slight to be given much attention, since an increase of 100 kilos per hectare of rough rice may easily be occasioned by any one of several other influences or by experimental error.

The number of bearing culms per square meter is usually regarded as a reliable indicator of yield yet a study of some of the data on file reveals that 12 plots averaging less than 200 culms per square meter yielded 0.154 kilo per square meter, 200 to 300 culms per square meter yielded 0.156 kilo, and 300 to 400 culms per square meter yielded 0.155 kilo. It will also be noted in Experiments 5 and 7, that the yield was not higher when the unusually large numbers of culms to the square meter were found than in instances where a much lesser number was produced.

It has been observed that a higher death rate of seedlings prevails in the close plantings than occurs in the more widely spaced ones.

The maturing period of the rice plant is not affected by the variation in spacing of hills. A variety closely planted matures in the same period of time as it does when the hills are widely spaced.

It is commonly believed that the early-maturing varieties may be more closely planted than the late-maturing sorts, and to a certain extent the results shown in the foregoing tables indicate the correctness of that opinion.

Under very intensive culture it appears that the proper spacing distance would have to be determined for each variety individually, also the approximate number of seedlings to be set in each hill. The tillering habits of varieties vary greatly and a distance satisfactory for a prolific sort would be altogether too great for one that stooled little.

In conclusion, one seedling per hill, provided with 100 square centimeters of area, evidently had all the room needed and was not able to fully utilize a greater area.

Two seedlings on 100 square centimeters evidently competed for plant food to the detriment of each other but when given 150 square centimeters of area there is no evidence of damaging competition.

If four seedlings are set in an area of 20 by 20 centimeters each seedling has 100 square centimeters of area to draw upon and the death of one seedling will make little difference apparently. It must be remembered that the full extension of the tillering habit depends on environment and, if the available food supply is abundant, the plants will quickly adapt themselves thereto by means of additional culms, so as to utilize it.

It therefore appears that with varieties maturing within $5\frac{1}{2}$ months, planting 3 to 5 seedlings to the hill and spacing the hills 20 centimeters apart in both directions will provide all the plants necessary to utilize the plant food available and yet not cause over-crowding. Furthermore such a scheme is practicable.

A hectare contains 10,000 square meters, and if hills are spaced 20 by 20 centimeters it will contain 250,000 hills, and, with an average of 4 plants per hill, one million seedlings. A cavan of rough rice, with grains of medium size, will contain about two million grains. It will therefore be seen that one cavan of seed is ample to provide seedlings to plant one hectare of land.

THE CAUSES OF LOW YIELDS OF RICE IN THE PHILIPPINES.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

The principal rice district of the Philippine Islands lies between Manila Bay and the Lingayen Gulf, embracing the five provinces of Bulacan, Pampanga, Tarlac, Nueva Ecija and Pangasinan, in which the area devoted to rice culture in 1914, according to statistics compiled by the Bureau of Agriculture, amounted to 432,141 hectares. This is slightly more than one third of the entire rice area in these Islands, which is 1,244,937 hectares.

The yield of rough rice in 1914 was estimated to be 22,736,814 cavanes of 43 kilos each, to which the five above-mentioned provinces contributed 8,987,729 cavanes, or 40 per cent.

In 1913, the area planted with rice in these five provinces amounted to 408,725 hectares, the total area for the Archipelago being 1,141,242 hectares and the yield of rough rice 13,147,495 cavanes, or about 53 per cent of the total production of the island group, which was 24,498,858 cavanes.

There were three other provinces in which the rice area exceeded forty thousand hectares during 1914, namely, Ambos Camarines, Capiz and Ilocos Norte. Big figures are impressive and often misleading, and in this case, the fact that even in 1913 the yield per hectare was not, by any means, as large as it should or could be, is not revealed until a more particular study is made of that feature.

It has become a very common experience to have pointed out to us the fact that our per-hectare yields are inferior to those of practically any rice-producing country whch has so far submitted statistics bearing on that industry.

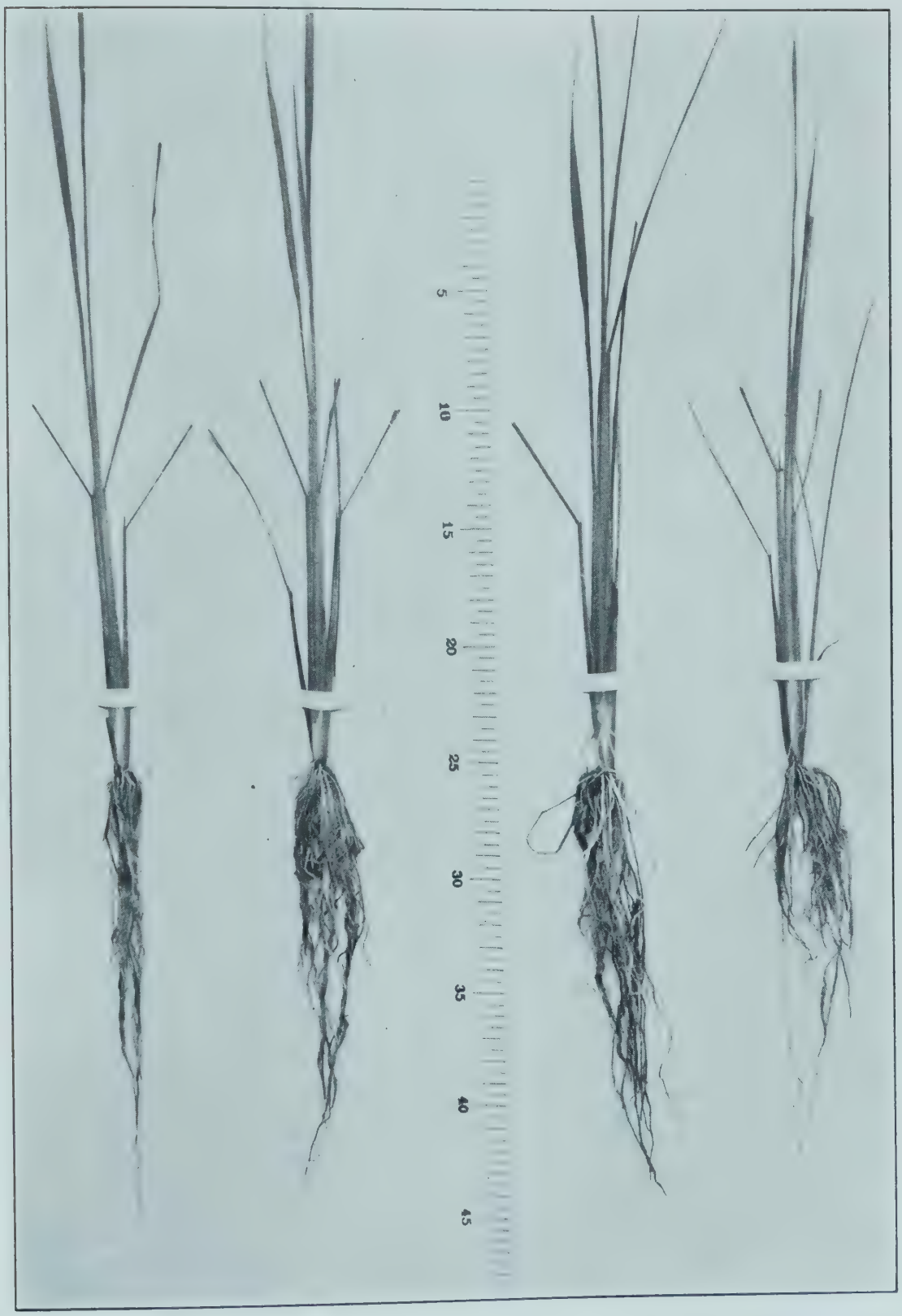
In searching for the cause to which the low average yields may be attributed, the most prominent and striking and perhaps unusual feature of the rice industry here is that all but a very small proportion of the area of cultivated land devoted to rice culture



An example of excessively close planting; an average of 18 plants for each 400 square centimeters.



The result of planting an excessive number of seedlings in the hill.



Types of seedlings; seed from same panicle; grown in same nursery bed. Note differences in structure.



Some mother plants produce many plants like the above. One of the causes of low yields.

is not under irrigation, even though as much as four-fifths of it is planted with lowland rice which requires an abundance of water for complete development.

In view of this fact the question arises as to whether the varieties of rice now cultivated are of such habits that they will fully develop and mature normal crops of grain with the usual supply of water which falls during the average rainy season.

For Tarlac, one of the representative provinces, we have the rainfall records for a period of twelve years, compiled by the Weather Bureau, also a record of the number of rainy days. In the first column is given the amount of rainfall in centimeters and in the second column, the number of rainy days in each month.

It will be noted that the actual rainy season is of shorter duration than is commonly believed, and, as well, much less regular. (See page 264.)

In this country, it is an axiom of the rice farmer that the rainfall must average a centimeter per day to make rice-growing conditions favorable.

According to the mean figures submitted for Tarlac, only July, August and September responded with a full quota of rainfall, with June and October of more doubtful value.

The second set of mean figures at the bottom of the table are those for Nueva Ecija. The bottom row of mean figures are for Pangasinan, the province having the greatest rice hectarage, and there we note June to September, inclusive, as satisfactory, but May and October as doubtful.

As yet no complete census has been taken of the varieties of rice grown in any of the several provinces, but one report compiled several years ago credits Bulacan Province with 117 varieties, Nueva Ecija with 235, Pampanga with 110, Pangasinan with 349, and Tarlac with 275. One province is credited with 525 varieties.

Obviously, it is quite improbable that as small a district as a province should have such varied soils and climatic conditions or divers demands to meet in the market that there should exist a necessity for such a large number of widely differing varieties.

Since the rainfall data for the Province of Tarlac have already been submitted in detail, we shall consider the varieties of rice grown there. As stated before, the 275 varieties reported may not constitute a complete list, but they are adequate for calculating reasonably accurate percentages. These are nearly all lowland sorts. The earliest-maturing variety requires 136 days from sowing in the nursery seedbed to attainment of complete maturity, the latest maturing, 219 days.

Record of rainfall and number of rainy days in the Province of Tarlac from 1902 to 1913, inclusive.

Year.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Total.	
	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.	Rainfall.	Days.
	Cm.		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*		*Cm.*	
1902					0.08	1	0.83	4	13.87	16	24.67	14	37.59	21	30.02	25	37.38	23	14.16	10	5.56	5	1.7	2		
1903	0.94	4	2.44	1	0.00	0	4.67	4	8.13	6	14.63	9	42.87	26	15.57	17	22.07	20	17.17	16	9.17	7	15.09	9	152.75	119
1904	0.08	2	0.28	1	5.59	1	2.34	2	9.14	11	49.51	18	40.92	22	21.90	21	38.40	24	14.45	12	3.00	11	0.20	4	185.81	129
1905	0.05	1	0.00	0	3.10	4	16.16	7	3.94	6	28.98	18	53.81	22	24.91	20	41.96	22	21.36	19	2.19	2	0.06	2	196.52	123
1906	0.61	3	0.48	3	4.57	5	6.38	6	47.86	14	14.15	18	22.36	21	36.98	21	49.01	25	36.53	15	13.61	13	0.79	4	233.33	148
1907	0.03	1	0.00	0	0.69	1	1.66	6	15.82	15	16.92	19	35.27	23	74.86	29	35.74	22	20.23	15	1.35	13	2.54	5	205.11	149
1908	0.58	4	1.08	3	0.30	1	5.05	3	34.65	21	26.27	15	48.65	23	51.73	26	30.64	18	30.54	19	28.85	9	8.16	4	266.50	146
1909	1.57	3	1.30	4	0.64	2	5.78	8	24.33	20	7.81	14	34.84	24	23.55	18	32.93	12	32.78	16	16.84	10	13.40	5	195.77	136
1910	0.08	1	0.10	1	7.88	7	8.36	6	32.99	15	10.79	11	21.36	18	25.63	22	36.13	21	7.33	10	8.11	13	1.12	3	159.88	128
1911			3.02	3	1.50	4	11.61	9	5.45	13	11.18	12	92.49	25	21.52	22	28.25	16	4.63	4	0.36	1	2.94	3	182.95	
1912	2.38	3	1.85	1	.97	1	4.90	3	11.43	9	36.41	20	42.96	22	44.82	27	31.55	21	19.02	16	7.97	13	0.87	1	205.13	137
1913	1.14	3	0.00	0	.97	1	11.22	5	15.23	11	27.66	16	29.47	25	35.80	24	36.64	22	11.43	12	0.99	3	4.14	3	174.69	125
Mean	0.75	2.5	0.96	1.5	2.19	2.3	6.58	5.2	18.57	13.1	22.42	15.3	41.88	22.7	33.94	22.7	35.06	20.5	19.14	13.7	8.17	8.3	4.25	3.8	193.91	131.6
THE DATA GATHERED AT TWO SEPARATE AND DISTANT POINTS IN THIS DISTRICT ARE APPENDED FOR COMPARISON.																										
1902 to 1907	1.02	1	0.67	1	0.80	.4	2.16	1.6	13.12	6.6	24.09	10.2	37.35	13.6	21.28	10.6	30.70	12.2	22.30	8.2	5.95	2.6	3.80	2.6	163.84	70.6
1902 to 1913	1.07	3.1	1.90	2.2	3.02	3.3	7.28	6.4	28.36	13.5	31.76	17.6	57.01	22.3	44.29	23.6	46.51	20.9	19.88	12.5	6.16	5.9	1.50	3.2	248.74	134.5

Classifying the varieties according to required periods to mature we find the distribution as follows:

Days to maturity.	Per cent.
150 or less	11.6
151 to 165	14.0
166 to 180	39.5
181 to 195	16.3
196 or more	18.6

Therefore, 74.4 per cent of the varieties now in culture require $5\frac{1}{2}$ or more months to produce the crop.

In order to fully appreciate the influence of maturing period on probable yield of grain, the records of 43 Tarlac varieties in plot tests, under irrigation, will be of interest. According to maturing periods the average production of rough rice per hectare is as follows:

Days to maturity.	Kilos.
150 or less	2,061
151 to 165	2,011
166 to 180	1,991
181 to 195	1,891
196 or more	1,358

It appears that with an abundant supply of water for irrigation purposes average normal yields will be obtained quite irrespective of the maturing period if it is found within rather wide limits. It also appears that even with the best of facilities for irrigation, there is nothing to be gained by growing the varieties which require more than six months to mature; on the contrary it is quite certain that the unusual season will so seriously affect the yield that the average for a ten-year period will be materially lower than with an earlier variety. Yet in this rice district under consideration 35 per cent of the varieties in culture are so late maturing that even under adequate irrigation, normal production of grain is bound to be hampered by sundry unfavorable conditions, and *but a small part of the district is as yet under irrigation.*

The rice farmer who has no irrigation water to draw upon cannot begin his field operations as early as he should.

Before he can sow his nursery seedbed he must have sufficient rain to soak the soil so that it may be properly puddled. After five months of bright, hot sunshine and without any heavy rains, a large amount of water is required to soak the soil so that it can be tilled. It thus happens, as a rule, that during a period

of 30 to 60 days of good rice-growing weather, the farmer is busy preparing the land for planting. And this is also the time in which the crop would make its best growth if already planted.

The question arises if it is good practice to plant the rice so early that it will be set out in the field when the regular rains begin. During the past six years we have begun sowing the nursery seedbeds at our experiment station in the middle of June, and nothing has yet occurred which would give us any reason for changing that practice.

Referring to the rainfall table we find, of the twelve years, only four in which without irrigation it was possible to begin plowing in May, namely, 1906, 1908, 1909, and 1910, but in three of these years the following month was so dry that operations probably could not be continued; this would cause replowing to be necessary in July before planting could be done.

In six years out of the twelve there was sufficient rainfall to permit the preparing of seedbeds and plowing in the fields in June, namely, 1902, 1904, 1905, 1908, 1912, and 1913. If the heavy rainfall in May of 1906 had been carefully husbanded perhaps that season might have been included.

Sufficient rainfall for all sorts of cultural work with rice prevailed in July of all twelve years, unless exception is taken to 1906 and 1910 when it was rather scant. For August, only 1903 was deficient in rainfall for rice which had been planted several weeks. September is notable for good rice-growing weather throughout.

In October, six years out of twelve the rainfall was inadequate for continuous normal growth of the rice crop. Varieties which had not passed the blooming stage during the early part of the month were undoubtedly considerably damaged.

November is usually a dry month, that is to say, the rains are expected to be infrequent and of small volume. However, one season, 1908, proved to be a rare exception.

Summarizing, we find that May must be disregarded as a month in which any cultural work with rice can be initiated. Granted that the seedbeds are sown in the middle of June, the seedlings will be ready for transplanting in the middle of July, and if five-month varieties are planted, three months of good growing weather is necessary to bring the crop safely through the blooming period, which will be about October 15. Ordinarily the October weather will permit this and in about five years in ten a 165-day crop will reach normal development provided it is planted as early as July 15. However, 74.4 per

cent of the varieties require a longer growing period and consequently suffer more or less nearly every season due to lack of sufficient moisture.

In 1914, the rainfall was irregularly distributed and inadequate, consequently the yield per hectare in Tarlac Province was 15 per cent lower than in 1913; in Pangasinan it was 40 per cent lower; in Pampanga 21 per cent; in Nueva Ecija 63 per cent, and in Bulacan 22 per cent. (The rainfall table is for the calendar year, and the crop statistics for the year ending June 30.)

In other words, with as favorable weather conditions as for 1913, or with earlier-maturing varieties, a normal yield would have been secured but, since the weather conditions were not suitable for a large portion of the rice district a loss in yield of more than six and one-half million cavanes was sustained, which would have had a money value in the provincial markets of more than sixteen millions of pesos. Last year, 1914–1915, in repeated instances, small fields of early-maturing varieties planted when the remainder of the crop was set out, produced normal crops, while hundreds of hectares were not even harvested because the grain failed to fill out.

It would appear that repeated disappointing experiences with these later-maturing varieties would result in their being eventually eliminated, but with the variation in annual rainfall it occasionally happens that a satisfactory yield is secured with these and the farmer hopes that the ensuing season will be as favorable.

There seems to be a prevalent belief that early maturity is synonymous with small yields, but such is not the case, except in the extreme instances. It is true that by certain practices a given variety can be forced to mature much earlier than it normally tends to mature, but this invariably results in lessened production.

On the other hand, it is also true that a goodly number of the late-maturing varieties are very productive, always provided conditions are such that they may develop normally.

Some of these last-mentioned sorts have been in cultivation for a long time, and have been mentioned by travelers as being seen in this country. In certain sections they are considered the proper ones to grow, and it is presumed that it is in these localities that the reputations of several of the better-known varieties have been built up.

One of the best-known variety names is Macan, yet there are

many distinct sorts bearing this name, and probably not a few other names are also applied to the true Macan variety.

Misapplication of variety names leads to much confusion not only with rice, but with other crops, bananas, for example.

A practice which has lead to many erroneous beliefs is the primitive method of estimating areas by the cavan. In ordinary usage a cavan of rice land is the area which a cavan (75 liters) of seed will plant; the Bureau of Internal Revenue regards a cavan hectare as of 10,062 square meters. When, for one thing, the great difference in number of grains to the liter of different varieties is considered, it is easily realized that with one cavan of small-sized grains a much larger area may be planted than with a cavan of large-sized grains. With transplanted rice an enormous difference in yield may result from the variation in spacing of hills and the number of seedlings set in each hill.

The relative merits of varieties are largely determined by the return harvested from the area planted with one cavan of seed, as fifty fold, one hundred fold, etc.

There are other factors which tend to prevent the rapid general adoption of earlier-maturing varieties, one of them being the insect *Leptocorisa acuta.* This pest, a common one, is nearly always present and causes a certain amount of loss. If, in a given district, the bulk of the crop is late maturing and a small part is early maturing, the insects congregate on the earliest-maturing rice and because of the restricted area they feed upon, the damage is very noticeable, sometimes amounting to a total loss of the crop. When the remainder of the crop begins to mature, the wide range for feeding then available to these insects renders the damage inflicted less perceptible, and the belief grows that it is a fault of the rice variety itself that brings the insect to it in such large numbers. Nevertheless the very late-maturing rice suffers equally as much damage as the very early for the same reason—restricted area.

The more progressive farmers realize that by planting large areas *enbloc* of the earlier-maturing varieties the damage done by the insect, if present, will not be so noticeable, but it requires a considerable amount of discernment and organization to effect this material change.

An objection quite frequently offered to earlier-maturing rice varieties is that they may mature during rainy weather and for that reason be difficult to harvest and that it may be more difficult to save the grain from damage by heating. There is

some reason for this objection and if irrigated lands were the rule instead of the exception, the most practical scheme would be to plant a variety which would ripen at the usual terminating date of the rainy season. Under prevailing conditions, however, it is a far more comfortable situation for the farmer to have a reasonably good crop each year even though it is necessary to harvest occasional ones under difficulties. It is a much simpler proposition to be forced to use extreme measures to save every alternate season's crop than to have but little or nothing to garner under more favorable conditions.

The failure of farmers generally to plant varieties of rice fully adapted to average rainfall conditions is the greatest contributing factor to the average low yields.

Next in importance is the continuation in culture of varieties, either early or late maturing, which have not sufficient productive power to yield large crop returns even under favorable conditions.

As has been previously stated (see Bulletin No. 22 of this Bureau, Rice Culture in the Philippines, p. 32), large percentages of varieties do not produce profitable yields.

According to the several classifications, varieties are divided with reference to average yields as follows:

	Less than 1,000 kilos per hectare.	More than 1,000, less than 2,000 kilos per hectare.	More than 2,000 kilos per hectare.
	Per cent.		
Non-bearded, non-glutinous, white, lowland	20.6	36.2	43.1
Bearded, non-glutinous, white, lowland	4.0	53.6	42.3
Non-bearded, non-glutinous, colored, lowland	12.7	40.4	46.8

Attention is called to the fact that the preceding figures are for plot tests under adequate irrigation and for that reason will show considerably higher rates of yield than would be the average under field conditions, where the water supply is entirely dependent on the amount of rainfall and its regularity.

An average yield of less than 2,000 kilos per hectare does not provide for sufficient profit to the farmer, so that he can maintain his industry in competition with the sugar planter or abaca grower.

Under ordinary conditions, only varieties that yield more than 2,000 kilos per hectare can be safely regarded as truly profitable.

Referring to the table previously given, we find the mean

percentage of varieties that exceed 2,000 kilos per hectare to be 43.38.

It is a safe assumption that two-thirds of the varieties now in cultivation, if excluded therefrom, would bring about a marked increase in average yields.

Assuming that the five provinces previously referred to are planted with an assortment of varieties as represented in the foregoing table, we can prepare a hypothesis which will be fairly representative of the effects actually resulting from the culture of a multiplicity of varieties.

The average production per hectare for these provinces in 1914 was 20.8 cavanes per hectare. To that average 17.6 per cent of the varieties contributed an average yield of 10.98 cavanes per hectare, which corresponds with those listed in the above table as yielding less than 1,000 kilos per hectare; 39 per cent of the varieties contributed an average yield of 24.34 cavanes per hectare; this class corresponds with the one listed as yielding more than 1,000 but less than 2,000 kilos per hectare. The remaining class of 43.4 per cent yielded at the rate of 27.08 cavanes per hectare, which brought the average up to 20.8 cavanes.

Since the exact area planted with each class is not known, a liberal assumption would be that only 13.4 per cent of the area was planted with the poorest-yielding varieties (although there is no doubt but that this figure is very low indeed), 44.5 per cent planted with the medium varieties, and 42.1 per cent of the area planted with the best-yielding varieties.

The estimated yield was 8,987,729 cavanes at the rate of 20.8 cavanes per hectare.

Thirteen and four-tenths per cent of the entire area yielded 635,819 cavanes because it was planted with the poorest-yielding varieties. If medium varieties had been planted the yield would have been 1,409,456 cavanes and if the highest-producing sorts only had been used, it would have been 1,568,122 cavanes.

Had the entire area been planted with only the most-productive varieties the total yield would have been 11,702,378 cavanes.

The loss in yield due to lack of productivity of varieties amounts to 2,714,649 cavanes which would have had a value of ₱6,780,000.

It is our opinion that even though the above ilustration is one constructed on a more or less theoretical basis the yearly loss due to planting poor-yielding varieties greatly exceeds the figures given.

As another illustration, we refer to the average results obtained with a large number of varieties in an experiment extending over a period of several years, on soil of very moderate fertility and with but one seedling to the hill, in which an average yield of approximately 40 cavanes per hectare has been uniformly harvested.

It would be a pleasure to be able to state that all rice land was given thorough culture before the crop was planted. In certain districts and again with certain individuals, thorough culture is the rule. Nevertheless, a large part of the rice lands is neither well plowed nor sufficiently harrowed. This is sometimes due to lack of animals but oftener due to the fact that the farmer does not appreciate the significance nor importance of reducing the soil in the rice fields to a fine condition of tilth.

Some preliminary investigations to learn the value of an extra harrowing given the soil just before transplanting takes place, indicate that greater gains than anticipated will result from more intensive cultivation of the soil. When the nature and character of the rice plant is understood it seems quite natural that the fine root system is better suited in a finely tilled soil where it can easily acquire the food required for the rapid development of the plant.

The matter of fertilizing rice soils has not yet been seriously considered by our rice farmers. Indeed, many of them seriously object to the application of cattle or horse manure, on the ground that the use of such material increases the weed growth in the fields.

Where the rainy season is short, there is very little opportunity for growing green manuring crops, nor leguminous crops to be planted after the rice is harvested. Reports on the use of chemical fertilizers vary greatly and unless such trials are very carefully handled the results may be exceedingly misleading.

There is much rice land which has not been cultivated for years and a great deal of virgin land that is being brought into cultivation. As long as land is a cheap commodity, the interest in maintaining or in increasing the fertility thereof is likely to receive scant attention.

The lack of irrigation facilities is a great handicap to the Philippine rice farmer, and until a great deal of rice area is placed under irrigation systems he will suffer more or less loss on account of periodic droughts, even though he puts into practice the best methods of seed selection, soil preparation, fertilization and culture.

It is an open question if a stable industry can be established without irrigation. With more or less expensive irrigation systems to sustain it is probable that more attention would be given to the culture of the crop, and, with control of water, the farmer would be assured of more uniform returns for labor expended, and would place a higher value on his tenure on land.

The lack of irrigation facilities looms very large among the factors contributing to low yields, but quite unfortunately it is the one factor which is most difficult and expensive to change.

On the other hand it is a very easy and inexpensive proposition to discard varieties which are not adapted to average meteorological conditions and to plant instead more suitable ones. The same applies to low-yielding varieties. It is also possible to more thoroughly work the soil.

THE RATE OF SOWING NURSERY BEDS; THE AGE OF SEEDLINGS WHEN TRANSPLANTED; THE INFLUENCE OF EACH.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

What is the proper quantity of seed to use on the seedbed? There are two views on this subject: one favors a small bed sown thickly, because it is cheaper to prepare and care for a small area, while the other favors a large area more thinly sown so as to secure more vigorous seedlings for transplanting.

The relative value of strong stocky seedlings compared with more tender, slender, or "leggy" plants with reference to their respective influence on ultimate yield is not easily determined, and only after a long series of carefully conducted tests would one be able to positively recommend definite rules for the best methods of preparation and treatment of nursery seedbeds.

Nevertheless the following data are offered for the consideration of others interested in the subject.

In 1913 a small experiment was carried out, employing a 140-day variety of rice and sowing the seedbeds with varying amounts of seed.

One-twentieth of a hectare was the standard area of seedbed determined upon and seed was sown at the rate of 2, 1.5, 1, 0.75, and 0.5 cavanes on this area.

There was no appreciable difference in the rate of germination of seed, which was found to be 75 per cent.

The seed was sown July 3 and a survey made of the nursery beds on July 24, three weeks afterwards.

The number of seedlings per seedbed was estimated by counting the seedlings on selected representative square decimeters, the average results being the basis on which the total population was computed.

According to the amounts sown the census was as follows:

Number of cavanes sown per 1/20 hectare.	Number of plants.
2	4,050,000
1.5	3,450,000
1	2,200,000
0.75	1,850,000
0.5	1,300,000

Practically no difference in height between the several plots was noticeable at this time. The inspector in charge of the work states that in his opinion all the seedbeds except the one most thickly sown were too sparsely populated and that even that one should have had about 12 per cent more seed.

The same scheme of sowing seedbeds was repeated at another point, and the comment made regarding this trial is as follows:

Observations made when the seedlings were ten days old and again when they were twenty days of age disclosed but little difference in the height of the seedlings in the most thinly sown beds when compared with those most thickly sown. The slight differences perceptible were to the effect that the former were slightly shorter and stockier.

At thirty days of age the seedlings in the two most thinly sown beds were coarser and more stocky than the others, and somewhat shorter. At forty days of age, the average heights of seedlings in all plots were practically the same, but in the plots where 2 and 1.5 cavanes of seed had been sown, the plants had smaller leaves and more slender stems, also in the centers of the plots the plants were inclined to lodge. The vigor and size of the seedlings progressed according to the scantiness of sowing.

It would naturally be anticipated that the stocky and sturdy seedlings would have an advantage over the more slender ones when transplanted, which would show a decided influence on the ultimate production of seed. This is not borne out by results so far secured. The average yield of one variety with seedlings from beds sown at the rate of 2, 1.5 and 1 cavanes to 500 square meters of seedbed was at the rate of 0.180 kilo per square meter compared with the yield of 0.133 kilo secured with the more sturdy seedlings taken from the seedbeds sown at the rate of 0.75 and 0.5 cavan per 500 square meters. With another variety the ratio was 0.258 kilo to 0.209 kilo, in favor of the more slender seedlings.

That there was any marked difference in the appearance of the seedlings grown in the three most thickly sown plots was hardly to be expected since relatively they were subjected to similar environment, so that the seedlings did not develop lateral shoots before being transplanted. It was quite apparent that they had fairly well exhausted the available plant food in their feeding area and the weaker seedlings were beginning to die or were already dead.

On the other hand, the seedlings in the beds sparsely sown developed quite differently, and it seems probable that a consider-

able difference in structure or development would have been found had the two types of seedlings been minutely compared.

It is commonly believed that the reason transplanted rice produces greater yields than does rice planted otherwise is due to the pruning process which takes place when the seedlings are withdrawn from the seedbed and prepared for planting, which injury to the root system brings about a reaction stimulating the growth of the sub-aerial portion and resulting in increased tillering. This theory does not take into consideration the fact that the seedlings when transferred to the newly cultivated field are removed from a position where the easily available food has, for the time being, been exhausted, to an environment where an abundance of food lies within easy reach; and in common practice there is retained a goodly portion of the roots which almost immediately resume their customary functions. Also these seedlings are transferred to a soil free from the toxic substances with which the original seedbed has been impregnated. Every farmer knows that no matter how carefully he replows and refits the seedbed, the plants set out therein do not thrive as they do in the common field, so it seems quite probable that toxins are at least partly responsible for the lack of vigor.

We have no desire to contend that the shock occasioned by the actual transplantation does not indirectly have a stimulating effect on the metabolism of the rice plant, but it seems that these other factors are more significant.

If in a seedbed the seedlings occupy not more than 2 square centimeters each, by the time they are five weeks of age there is practically no immediately available plant food remaining, the weakest ones succumb, and those surviving compete to the utmost for the plant food that is slowly being evolved. The root systems are not extensive nor is the leaf area large, neither is there any development of lateral culms. For the reasons stated these plants should suffer the least shock on being transplanted.

On the other hand the seedlings grown in the sparsely sown beds have when 5 to 7 weeks of age, a large leaf area and, of course, a correspondingly extensive root system, usually the first node having been formed and lateral culms having developed. When such a seedling is removed from the seedbed the shock to it is correspondingly greater because a larger proportion of its root system is lost, and, even though a considerable part of the leaf surface is removed, the relative bulk of plant remaining is greater than is the case with the previously mentioned sort of seedling. The shock to this stocky and sturdy seedling must be greater than it is to the slender and more delicate plant, and, if

the contention is well founded that the shock is the cause of the stimulus resulting in accelerated stooling or tillering, the well-developed seedling should possess a marked initial advantage.

It may also be said that, to a limited extent, the seedlings grown in the sparsely sown seedbed are somewhat pampered, while those grown in the thickly sown bed are subjected to a test for the survival of the fittest.

If rice is to be transplanted, it seems logical that this change should take place at such a time as tillering is due to begin, for, if given a stimulus at that time, it is reasonable to suppose that a greater extent of tillering will take place than without it.

Those who are familiar with sheep husbandry know about the "flushing process" practiced on the ewes in order to secure a larger percentage of twin offspring. It is not beyond the range of possibilities to assume that if this phenomenon in sheep, induced by means of super-complete nutrition, predisposes accelerated reprodution, a stimulus given a plant by means of abundant food supply will as well induce a similar result.

The tillering of a plant is only one stage of the act of reproduction and takes place within a definite period of its development. If at this time food is abundant, the plant will extend itself to the limit of its power to utilize this food. After that period is over it cannot respond to nutrition stimulus in this manner.

It is the writer's belief that, when the rice plant is more intimately understood, it will be learned that a provision of an abundant supply of available plant food, principally nitrogen in some form, will be regarded as essential at this stage in intensive rice culture, and that the farmer of the future will incorporate the idea in his practice.

While we do not regard the results we have secured as conclusive, our data reveal the fact that the ratio of stooling or tillering of seedlings grown in thickly sown seedbeds to that of seedlings produced in sparsely sown beds is as 14.8 to 10.5. In these studies the seedlings have not been continued in the seedbeds over 40 days.

This important point has more light thrown upon it when the effect on yield of the age of the seedling when transplanted is sought.

In order to secure some information on this point a test was carried out as follows:

A medium-early variety was sown in the seedbed on July 3, and plots were planted with seedlings therefrom on July 23, and August 2, and August 12, so that the seedlings were 20, 30 and 40 days old, respectively. Again, seedbeds were sown at ten-day

intervals so that at a given date seedlings of 20, 30 and 40 days of age could be transplanted into test plots simultaneously.

The results are given in the table below and are representative of the several tests completed the first season.

Age of seedlings.	Days to maturity.	Days from transplanting to maturity.	Average—			
			Length of culms.	Number of culms per stool.	Number of grains per panicle.	Yield of rough rice per square meter.
			Cm.			*Kilo.*
20 days	132	112	122	4.35	100	0.203
30 days	137	107	121	4.30	96	.171
40 days	139	99	124	6.20	88	.179

A repetition of this experiment with three varieties yielded the following results. These varieties mature within 142 days on the average.

Variety and age of seedlings.	Days to maturity.	Days from transplanting to maturity.	Average—			
			Length of culms.	Number of culms per stool.	Number of grains per panicle.	Yield of rough rice per square meter.
			Cm.			*Kilo.*
No. 629:						
20 days	115	95	99	11.2	94	0.083
30 days	126	96	82	12.1	99	.156
40 days	134	94	79	12.0	92	.160
No. 526:						
20 days	119	99	105	7	102	.142
30 days	130	100	91	8.2	108	.212
40 days	145	105	86	10.2	107	.164
No. 530:						
20 days	117	97	118	15.5	128	----------
30 days	126	96	109	12.8	127	----------
40 days	137	97	105	12.5	126	----------

Still another experiment was made in which 70, 60, 50, 40, 30, 20 and 13-day old seedlings were planted in which three varieties were used having maturing periods of 136, 156, and 178 days respectively.

Only the relative yields are indicated.

Age of seedlings.	Yield per square meter.		
	136 days to maturity.	156 days to maturity.	178 days to maturity.
	Kilo.	*Kilo.*	*Kilo.*
70 days	0.016	0.016	0.061
60 days	0.112	0.162	0.147
50 days	0.112	0.131	0.028
40 days	0.167	0.056	0.049
30 days	0.085	0.085	----------
20 days	0.022	0.019	0.032
13 days	0.016	0.018	0.025

One can hardly come to any other conclusion from the foregoing than that the age of the seedling is itself not a guide to the determination of the most suitable time to transplant the seedlings, since their condition at that stage depends upon the manner in which they have been produced and varies accordingly. Also, if seedlings are transplanted at the proper stage of development, the importance of a given rate of sowing the seedbeds is of rather small consequence.

In bulletin No. 22 of this Bureau, "Rice Culture in the Philippines," page 23, the author thereof states, "For transplanted rice one cavan or 43 kilos of palay seed is sufficient for one hectare; When sown broadcast it requires one-half more;" on page 18 of the same bulletin, "One-twentieth of the area to be planted is required for the seedbed. * * * As soon as the ground is prepared the seed should be put on at the rate of 43 kilos (1 cavan) for each one-twentieth hectare of seedbed. Some use more and some less. The amount will be governed somewhat by the variety."

In our opinion these directions will, for the present, serve as a standard until such a time as it is definitely determined that thicker or thinner sowing of nurserybed has a positive effect on the seedlings which influences the ultimate production of seed.

It is a more difficult and complicated matter to make recommendations regarding the proper age at which seedlings shall be transplanted, and, while one is sometimes forced to make definite recommendations, it should be understood that very many practices in rice culture are as yet based on convention, and much careful research must be made before specific recommendations or instructions may be safely considered as authoritative.

Investigations with regard to rice culture have only just been begun, so that in most cases the results secured indicate the direction in which further research should be carried, rather than the establishment of positive facts. With the limited resources at our command we have touched upon many very interesting points sufficiently to show us the importance of laying out and definitely following given lines of research. We have learned to recognize some of the more common sources of error in experimental work and how to guard against them.

For instance, when two series of plots are transplanted at different dates, even if only a few days apart, the influence exerted by a slight difference in the weather during this short period may easily be sufficient to utterly destroy the value of the data obtained.

We have regarded 30 to 35 days as the most suitable age at

which to transplant seedlings of varieties maturing within 150 days. At the same time we have realized that it is quite probable that each variety has its own peculiar habit which would more definitely determine the proper time for its removal to the field, but the determination of this fact requires considerable time, and meanwhile one must be guided by the data available until better and more definite information is obtained. It has been our experience that the earlier varieties, when the transplanting is deferred too long, mature the central culm in advance of the lateral ones, so that the grain on these culms is lost and, besides, an uneven appearance is presented by fields planted with such seedlings.

Tillering is but one among other very important habits which the several varieties possess in a varying degree and, even if this is the most elastic method by which a plant adjusts itself to its environment, this habit is, according to our present understanding, an important indication of the productivity of the variety. If the tillering habit is curtailed by unfavorable conditions early in life, the effect thereof will probably extend throughout, but, on the other hand, if the plant is provided with an opportunity to fully exercise its tillering habit during the early period of its growth, provision is then made for the exercise of the other functions which are in turn dependent upon environmental conditions prevailing during the respective stages of development.

The plant should be allowed to exercise its tillering habits normally. That does not mean that it should have an unhampered opportunity to tiller to the limit of its capacity, but the seedling should be produced in such a manner and be transplanted at such a stage in its development that neither the early environment nor its condition when transplanted will tend to prevent the normal exercise of its capacity to tiller. The restrictive influences of lack of plant food or moisture, or in other words, competition in the field, will probably not have much serious effect, if any.

There is some relation between amount of tillering and production of seed, but it is more than likely that other development incidental to the act of tillering is of more importance. It seems, therefore, that we shall also be obliged to determine the proper stage of growth at which each variety shall be transferred from the nursery seedbed to the field.

ERRORS IN RICE FERTILIZER EXPERIMENTS.

By H. O. Jacobson, *Chief, Plant Industry Division.*

When an effort is made to increase the yield of any crop, the first aid sought is usually fertilization. Even primitive people recognize the difference in productive powers of soils, and an illustrative phrase, referring to "fat" land and "poor" land, is found in nearly every language.

There is no other single topic today in the field of agriculture which is given so much thought, discussion and investigation as that of maintaining soil fertility, or in other words, the feeding of crops.

In the treatment of nearly all staple crops, conditions are quite similar, such as providing for drainage, soil aëration, etc., but with lowland rice entirely new conditions are met with, and we have no assurance that a method found very valuable when practiced with wheat or barley, for instance, will be of any use whatever when applied to rice grown in puddled, submerged soils.

It is a well-known fact that many so-called fertilizing experiments are unreliable because the investigators in charge of the work have failed to realize the significance and effect of other factors bearing on results obtained. Thus we find lengthy discussions leading to quite final conclusions, even though the condition and status of the soil with regard to initial content of plant-food elements is unknown; the degree of soil acidity undetermined; the previous cropping of the soil disregarded; and countless other more or less important factors overlooked.

We have in mind a paper describing very definite results obtained in fertilizing lowland, or irrigated and transplanted rice. Various amounts of several sorts of animal manures were used but nothing is said about their actual composition; part of the land was plowed dry, then flooded and harrowed, while the remainder of the area was flooded first and then plowed and harrowed; and to complicate matters, neither was there any attention paid to the actual amounts of water applied nor was the area

planted on the same day. Yet the public is solemnly assured that the differences observed in yield were solely due to the effects of the fertilizers applied.

There is no desire to decry or criticize the efforts of those who are attempting to solve the problems involved in the feeding of the rice crop, or any other crop for that matter, for every definite knowledge on this subject is sorely needed.

One of the great wastes in modern agriculture is the unintelligent use of artificial and animal manures. Thus we find nitrogen being applied when not needed, and phosphorus withheld when nothing else is actually necessary; a complete fertilizer used when the neutralization of acidity would serve better, and so on.

Artificial fertilizers are, according to our present knowledge, very important factors in the economics of agriculture and present-day public opinion regards the increased use therof as a reliable indicator of high development of agricultural practices.

The writer desires to call attention to the necessity of exercising greater care in the management of experiments, the results of which are to be submitted to the public for their guidance.

As an illustration of the very misleading deductions which might be drawn from even a comprehensive experiment, a short description of such a one is given below.

A plot of ground which had not been cultivated for a year was selected, in which the soil was uniform in character and composition.

One series of the experiment was designed to indicate the effect of nitrogen alone in varying amounts and in combination with phosphorus or potassium and in combinations with both.

The same scheme was used with phosphorus and potassium, so that a large number of combinations were made, 38 in all. Sulphate of ammonia, acid phosphate, sulphate of potash and tankage were the materials employed. The chemical analysis of each was determined. The tankage was used only on two duplicate plots. Provisions were made so that water could be admitted direct to each plot and drawn off into drainage canals. As far as could be seen every precaution was made to provide uniform conditions, but there was one exception. Due to accident nine plots were set out July 29 and 30 and the others on August 7.

When harvesting was begun the lack of uniformity in duplicate plots was very discouraging, but it prevailed throughout. At

any rate, it was possible to consider the original plots as a class, the duplicate plots as another. The results were as follows:

Average yield of rough rice per hectare:	Kilos.
Unfertilized area	1,520
Fertilized area	1,483

Twenty-one per cent of the area was not fertilized in any manner whatsoever. It so happened that of the plots planted July 29 and 30, two were not fertilized, four had complete fertilizers, and three had incomplete fertilizers.

The area planted July 29 and 30 yielded at the rate of 1,745 kilograms rough rice per hectare, while the area planted August 7 returned 1,409 kilograms per hectare.

It is evident from the foregoing that the variation in yield was due to some other cause or causes than the influence of the fertilizers; yet it would be possible to put the data into such shape that it would indicate utterly misleading and erroneous conclusions.

CONSUMPTION OF RICE IN THE PHILIPPINE ISLANDS.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

Of late one is often confronted with the statement that the per-capita consumption of rice in the Philippine Islands is gradually falling off.

Those who have been closely observing the habits of the people claim that the consumption of wheat flour is increasing so rapidly and extensively that it will have a strong tendency to lessen the consumption of rice. It is, of course, a well-known fact that a few years ago, in the more out-of-the-way places, it was impossible to procure bread in any form, while now the bake-shop is found in even the most isolated sections. There is no doubt that the use of flour is increasing, but the question remains if the increasing use of flour has any effect on the consumption of rice.

The production of wealth in these Islands has been greatly accelerated during the last decade, the exportation of copra serving very well as an example of this. In 1899 the value of the copra exported amounted to ₱1,313,740; ten years later the figure was ₱13,315,480, while the high point attained in 1912 brought the amount to ₱33,029,498. The prosperity of the people has become general during the past ten years, wages have gone up and the field for profitable employment has been vastly enlarged.

Public works and railroad construction, the extension of industries such as mining and lumbering, the extension of Government service in many branches, thus providing large numbers of remunerative positions, the establishment of numberless new enterprises, etc., have, through providing more lucrative employment, had noticeable effect on raising the standards of living. It may be true that the increase in incomes has had less effect on dietic standards than on others, the improvement in housing, the purchase of better clothing and so-called luxuries having been perhaps the more common outlet for surplus earnings. Nevertheless, a certain amount of change in food is bound to be consequent upon more favorable economic conditions.

It is not necessarily the case that there should be a greater consumption of more expensive grades or qualities of staples, but there may be an increasd amount per capita consumed of staple articles of food of the prevalent grade or quality.

It has been argued that a population such as is found in these Islands does not consume as much rice as it should; that because much of it is found in places where not enough rice is grown for home consumption, the cost of transportation is so expensive that the price of rice becomes too high and other less desirable articles of food are substituted; that the increased use of flour, Irish potatoes or corn, if actually being consumed in larger amounts, is not a desirable change, and, therefore, any scheme by which a sufficiency of rice can be provided at reasonable cost is much to be desired and will result in an increased per-capita consumption of rice.

According to the census taken in 1903 the population of these Islands was 7,635,426. Using the method of computing population increase employed by the Bureau of Health we find the population in 1914 exceeding nine millon by a margin of some eighty-odd thousands.

It is not only possible but highly probable that the population now exceeds the estimate by a large figure. Due to better and more extensive enforcement of sanitary regulations, to the control of epidemics, and to better nourishment, it is reasonable to anticipate that the increase of population has been going on at a considerably greater rate than is assumed. On the other hand, the crop estimates may have sufficient range so that the error in one factor will counteract the error in the other.

The amounts of rice produced and imported, corn produced, and flour imported, are given in the following table:

	Rice imported.	Rice produced.	Corn produced.	Flour imported.
	Met. tons.	*Met. tons.*	*Met. tons.*	*Met. tons.*
1909	137,678	487,032	----------	25,932
1910	184,620	528,054	144,353	29,492
1911	203,083	574,843	145,396	30,786
1912	260,250	325,429	214,473	40,148
1913	179,205	685,968	253,851	49,890
1913 (July to December)	49,562	----------	----------	16,221
1914	[a] 96,921	636,609	366,570	35,513
1915	[b] 183,267	[c] 500,000	----------	----------

[a] Calendar year. [b] First nine months. [c] Estimated.

NOTE.—Production estimates are for years ending June 30.

In order to get a better idea of the bulk of rice annually consumed, the imports and estimated production are combined. The

per-capita consumption of rice, corn and flour is submitted in this connection with comment following below.

	Total rice.	Rice per capita.	Corn per capita.	Flour per capita.
	Met. tons.	*Kilos.*	*Kilos.*	*Kilos.*
1909	622,710	74.17		3.09
1910	712,674	83.55	16.92	3.11
1911	779,926	89.77	16.78	3.55
1912	585,679	66.52	24.36	4.56
1913	865,173	96.72	28.38	5.58
1914	783,096	86.18	40.34	5.69

That the consumption of flour is continuous and progressive is clearly evident, and there is no indication that shortage or abundance of rice have any influence upon it.

It should be explained, however, that the importations of flour made during the period from July 1 to December 31, 1913, were included with the 1914 total.

There are several good reasons for assuming that with the unusually large importation of flour during the year ending June 30, 1913, a considerable amount was carried over into the next period. Nevertheless, it would be quite reasonable to suppose that the upsetting of business conditions following the beginning of the European war would operate to lower consumption both in 1914 and 1915, but under normal conditions there is no doubt about the figures submitted being indicative of true conditions.

Considering the consumption of corn, several questions arise. Generally speaking corn has been the famine crop, catch crop, or poor man's food, but the more recent educational work conducted and directed by the various Government offices has undoubtedly done much to change public opinion regarding this grain. From 1910 to 1914 the area devoted to the production of this crop increased 46 per cent and the yield per hectare 74 per cent.

Primarily the grain is intended for human food. Only a very little is used in the industries, and grain feeding of swine, cattle, horses and poultry is not so universally practiced as it might be. However, the large crops produced in 1912, 1913 and 1914 have in part and even to a considerable degree, from necessity, been utilized for other purposes than for human food. A certain amount of rough rice is always used for feeding horses and poultry, but if corn becomes much cheaper than rough rice, the corn will be subtituted for it.

In 1912, there was probably more corn used for human food than either before or since that time, but the amount of grain

utilized for other purposes has very materially increased each year thereafter.

According to one authority the Japanese consume 105 kilos of rice per capita per annum. Since they live in a colder climate and are more active people, they would require more than the people in these Islands.

The writer is of the opinion that 85 kilos of rice per capita per annum is the normal figure for the Philippines, but there is no doubt but that this figure would be larger if more favorable conditions prevailed.

To refer to the table, the figures given for 1911 as the amount of per-capita consumption of rice should undoubtedly be lowered by distribution to 1910 and 1912. The figure given for 1912 is too low, because a considerable portion of the total amount included in the import and production figures for 1913 should properly be distributed over the preceding period.

In computing the figure for 1914 the rice imported during the period from July 1 to December 31, 1913, is included for the reason that it represents the amount carried over in storage from the preceding period.

When we come to consider the 1915 figures we are confronted with an anomaly.

The rice crop of 1914–15 was very seriously damaged by an unusually severe drought which began about October first, and continued without hardly a break worthy of mention until July of the present year.

This drought cut down yields in the principal rice-producing sections to an unusually low point. The subsequent dry season was characterized by phenomenally intense heat over long periods.

The surplus rice carried over from 1914 was probably not of great consequence.

Naturally, it was anticipated that the importations of 1915 would break previous records, yet by October first only 183,267 metric tons had been received. The average rate of rice importation into the Philippines is 15,000 tons per month. This amount represents the average monthly receipt over a period of sixteen and one-half years.

By October considerable new-crop rice appears in the provincial markets and the amount rapidly increases weekly for the remainder of the year. The peculiar fact, however, is that the importation of rice does not always directly arise from the need for it here for immediate consumption or even for use at a rel-

atively distant date such as a matter of a few months. As a matter of fact, even though the new crop of rice was rapidly coming on the provincial markets, and reserves of rice lay in the warehouses awaiting an outlet, big shipments of rice were brought into the Philippines and distributed for which at the time there was no apparent need.

We faced an unusual situation a year ago which was generally recognized soon after the war between the European nations had been declared. This was that the Archipelago was dependent to a vital degree on its neighbors for a given amount of rice, which supply might be shut off, and at the same time, was experiencing an unprecedented drought which curtailed local production.

The need for action was very apparent and immediately a general food-production campaign was inaugurated by the Bureau of Agriculture in which several other Government offices participated. In this campaign the production of corn, sweet potatoes and vegetables was strongly emphasized with the result that never before had there been such a supply of vegetables in general as came upon the market in the succeeding season. This was a new element in the local food supply and one of considerable magnitude. At any rate, the amount of corn produced is estimated to be nearly double that of 1912. The effect on rice consumption of the abundance of vegetables remains to be determined but it seems that the abundant supply of both corn and vegetables lowered the demand for rice, especially during the early part of the year.

The total amount necessary to supply 85 kilos of rice per capita would amount to 784,721 metric tons for 1915. Of this amount 183,267 had been received by October 1, and there were, according to various reports, sufficient stocks on hand to render further importations unnecessary. Although the 1915 rice area was larger than for the preceding season the total crop was estimated to be 500,000 metric tons, which amount, if the estimate is correct, does not quite supply the usual quota per capita when the imported rice is added. The large corn crop was most in evidence during the first part of 1915 as was the produce resulting from the food campaign.

There is nothing to show that there is any tendency towards lessened consumption of rice by the human population. The abundance of corn is probably the means of increasing rice consumption instead of lowering it, for if corn is cheaper than rice, it will be used for purposes for which rice has formerly

been utilized with the result that the rice will be kept for actual consumption as food.

Flour, in the limited amounts used, has little if any influence on the average consumption of rice. Its use may be regarded as an addition to a still inadequate supply of food. Under good economic conditions its use will increase because of its convenience and because of the mere fact that it supplies a much-to-be-desired variety; also it will enter more and more into the composition of the more complicated dishes.

THE WEIGHT OF RICE GRAINS.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

It is not long since the question of the relative value of large-sized seeds compared with small-sized seeds was discussed with considerable interest. There was not much assurance to be had as to whether seed size was a stable transmitted character or not, but the assumption was that large seed was so much more preferable to smaller seed that considerable expense could be incurred in order to secure such material, which would surely be compensated for by increased yield.

Everyone is familiar with schemes and devices for making mechanical selection of large and heavy seed for planting, and the lengthy discussions on the subject are at least interesting.

More recently, less attention is being given the matter, and, according to the results announced by those who have been doing selection work within pure lines, the prospects are that relative seed size will soon be considered as of importance only with regard to the influence it may have on the early development of the plant after germination.

With rice very little attention has been given to the matter of learning the position or location of the largest grains on the panicle.

Japanese investigators assert that the largest, or to be exact, the *best* grains occur in the upper third of the panicle.

Dr. J. Van Breda de Haan, in Java, having examined seventeen varieties finds that fourteen of these have heavier grains in the upper half of the panicle.

In making these determinations the panicle was divided at about the middle of its principal axis in such a manner as to permit the division to be equal as to the number of grains.

The grains were weighed in the hull and also after the hulls were removed.

When the panicle was divided into three parts, the upper third was usually the heaviest.

In our work we have examined fifty-eight of our varieties.

The panicle was divided into three portions, the division being based primarily on the branches so as to have an equal number in each portion. Sufficient panicles of each variety were taken to provide a number of such magnitude that the weights per thousand grains would be reasonably accurate.

It was found that in 24 varieties the heaviest grains were found in the upper third of the panicle, in 20 varieties in the middle portion, and in 14 varieties in the base.

The mean figures for all weights taken show that the weight of 1,000 grains from the upper third was 25.86 grams, the middle, 25.62, and the base, 25.45.

There is a very slight difference in weight in favor of the grains from the upper portion of the panicle, which is anticipated when dealing with a large number of varieties, but after all, the knowledge of this fact is of doubtful value in the work of increasing yield. In the first place the weight per 1,000 kernels does not appear to be as stable a character as has been believed, and must therefore be affected by environmental conditions prevailing during the maturing period.

We have yet to learn if the weather and the plant-food supply are not the cause of the difference observed in the weight of grains in the different portions of the panicle.

The observations made by Dr. Van Breda de Haan with regard to the fact that the grains on the secondary axes are heavier the nearer they are to the principal axis, agree with observations made here.

A table giving the names of varieties and the weight per 1,000 grains in grams, according to position on the panicle, is appended.

In the opinion of the writer, the question of seed size is of slight importance compared with other problems yet unsolved.

Table giving the names of varieties and weight per 1,000 grains in grams, according to position on panicle.

Variety name.	Weight per 1,000 grains in grams according to position on panicle.			Variety name.	Weight per 1,000 grains in grams according to position on panicle.		
	Top.	Middle.	Base.		Top.	Middle.	Base.
1. Alasan Diquet No. 1	23.10	25.18	25.20	28. Gumiki	25.72	26.50	26.00
2. Alasan Diquet No. 2	31.50	28.50	26.50	29. Ganado	23.90	24.85	23.28
3. Alumisque	29.90	30.50	30.00	30. Gracia	25.65	25.50	25.30
4. Bimmaka	30.00	27.50	28.70	31. Inugnas	23.75	23.77	22.00
5. Buntayug	19.76	20.85	20.00	32. Immaramang	32.05	31.37	27.98
6. Binanata	29.44	29.50	28.50	33. Kayading	32.13	31.15	33.15
7. Bancado	27.00	25.90	26.55	34. Largavida	23.55	22.52	22.25
8. Baro	21.15	22.45	20.75	35. Lacay Diquet	29.15	27.45	25.71
9. Bandera	24.85	25.40	24.80	36. Malatican	31.60	30.15	32.90
10. Balasang	23.95	22.90	23.75	37. Malaga	28.95	28.45	25.35
11. Boncol	24.45	22.70	24.34	38. Marimata	27.10	26.60	24.87
12. Bacculoy	25.00	23.85	23.74	39. Murmuray	25.10	24.30	24.65
13. Chayaket Kinol-long	24.83	24.83	25.05	40. Maralisa	22.45	24.20	22.79
14. Chayaket Likwet	25.70	26.94	25.54	41. Mudson	20.20	21.30	21.32
15. Chayaket Cabugao	27.30	26.25	26.15	42. Minantica	20.55	21.45	21.20
16. Chinaigo	23.58	23.95	23.75	43. Oday	34.60	35.70	33.58
17. Chayaket	27.61	26.50	28.15	44. Pinili	25.00	23.65	25.79
18. Contenido	22.35	22.40	20.15	45. Pugut Diquet	28.20	27.22	24.88
19. Canal	29.80	29.35	29.75	46. Pias	31.68	30.90	30.45
20. Chayaquet Immigan	24.37	24.05	23.05	47. Quinatuday	26.68	25.83	26.25
21. Diquet Kuantian	25.70	25.45	27.95	48. Quiringquiruig	27.00	26.18	26.69
22. Diquet Kayading	26.46	24.30	24.20	49. Sabor	26.00	24.90	27.66
23. Daligan	24.70	26.62	26.76	50. Sabá	20.60	20.95	23.74
24. Dalusun	21.25	21.27	20.40	51. Saigorot	32.96	27.98	30.95
25. Fiscal	24.10	26.00	26.68	52. Sinaba	28.00	28.15	28.10
26. Guepang	25.21	26.75	27.10	53. Sanglay	28.10	26.95	25.82
27. Gumguiriada	22.73	23.30	21.85	54. Sinana	21.25	22.25	22.02
				55. Tiritir	21.50	22.46	22.10
				56. Tiritir Nalabaga	24.83	25.50	24.60
				57. Trauguilina	23.58	23.57	22.70
				58. Yucan Diquet	22.17	21.17	22.59

AN EARLY REFERENCE TO PHILIPPINE RICE VARIETIES.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

In a volume published in 1854, entitled "The Commercial Products of the Vegetable Kingdom," of which P. L. Simmonds is the author, a reference is made to Philippine rice varieties which is at least of passing interest.

A Mr. Rich, a botanist of the United States Exploring Expedition, is credited with having supplied the descriptions of the following varieties:

Binambang.—Leaves slightly hairy; blumes whitish; grows to the height of about five feet; flowers in December: aquatic.

This variety is still grown in the Provinces of Rizal and Laguna.

Lamuyo greatly resembles the above; is more extensively cultivated particularly in Batangas, where it forms the principal article of food of the inhabitants of the coast: aquatic.

We have no data or record of such a variety and it is not now cultivated in Batangas, to our knowledge.

Malacquit.—This variety derives its name from its being very glutinous after boiling; it is much used by the natives in making sweet or fancy dishes; and also used in making a whitewash, mixed with lime, which is remarkable for its brilliancy, and for withstanding rain, etc.; aquatic.

Malagkit is a term designating the class. The word has a specific meaning—glutinous. Thus we have on record thirty varieties known ordinarily as Malagkit, but usually in conjunction with the specific variety name, as "Malagkit Kinastillo."

Bontot Cabayo.—Common in Ilocos, where it is cultivated both upland and lowland; it produces a large grain, and is therefore much esteemed, but has rather a rough taste.

The meaning implied by the name is that the panicle is like a horse's tail, therefore, having long awns. Although known to be found in Pangasinan, Zambales and the Ilocos provinces, it is not a popular variety now.

Dumali, or early rice.—This rice is raised in the uplands exclusively, and derives its name from ripening its grain three months from planting; the seed is rather broader and shorter than the other varieties; it is not extensively cultivated, as birds and insects are very destructive to it.

Dumali may be regarded as a class designation, although it is a specific name for one variety. The word or name implies early or quickly maturing. The variety referred to is still grown in Batangas Province.

Quinanda, with smooth leaves.—This variety is held in great estimation by the people of Batangas, as they say it swells more in boiling than any other variety; it is sown in May, and gathered in October; upland.

Kinanda is a well-known variety grown in Batangas and Cavite Provinces. There are six varieties of Kinanda and three more to which the name is applied as a descriptive adjective, as "Kinandang Puti."

Bolohan.—This variety has very hairy glumes; it is not held in much esteem by the natives, but it is cultivated on account of its not being so liable to the attacks of insects and diseases as most of the other upland varieties.

Buluhan signifies hispid. The variety known by this name is hardy but not very productive. The variety known by the specific name is found in Batangas Province but there are nine additional varieties in which the word Buluhan enters as a part of a compound name.

Malagcquit.—With smooth leaves, and red glumes (all the preceding are whitish); possesses all the qualities of the aquatic variety of the same name—that of being very glutinous after boiling. This rice, soaked in water with the hulls on, is said to be a remedy for worms in horses; it is given with honey and water.

Malagkit=glutinous (Tagalog).

Tangi.—Leaves slightly hairy, glumes light violet color. This upland variety is held in much esteem for its fine flavor.

This variety is not known to the writer. The name signifies that it is a special or unusual sort. It may be a case, however, of failure to distinguish between two very similar names. In Batangas Province a variety is still being cultivated which is called Tangui.

A PHILIPPINE WILD RICE.

By H. O. Jacobson, *Chief, Plant Industry Division.*

In December of 1913 our attention was called to a new species of rice, but the material then secured was inadequate for determination, so an attempt was made to obtain an entire plant and some mature seeds.

These were secured in April of 1914 in Gubat, Sorsogon. Mr. E. D. Merrill, botanist in the Bureau of Science, identified the species as *Oryza manilensis.*

In an article entitled New or Noteworthy Philippine Plants, VI, published in the August, 1908, number of the Philippine Journal of Science (botanical section), this species is described by Mr. Merrill as follows:

Oryza manilensis sp. nov.

Annua, erecta, 1 ad 1.3 m alta; foliis flaccidis, 10 ad 25 cm longis, 6 ad 7 mm latis; paniculis laxis, 10 ad 15 cm longis, flaccidis, paucifloris; spiculis 4 mm longis, arista 8 ad 10 mm longa.

An annual 1 to 1.3 m high. Culms slender, glabrous, the nodes, 6 or 7, glabrous. Leaves flaccid, minutely scabrid when dry, 10 to 25 cm long, 6 to 7 mm wide; sheaths rather loose, shorter than the internodes, the ligules about 2.5 mm long. Panicles lax, 10 to 15 cm long, the branches slender, scabrid, usually drooping, few-flowered. Spikelets 4 mm long, the empty glumes narrowly lanceolate, acuminate, 1.5 mm long. Flowering glume oblong, granulate, spinescent-ciliate on the keel and ribs, its awn slender, straight, 8 to 10 mm long. Palea slightly exceeding the flowering glume, short-acuminate, spinescent on the keels.

Luzon, Province of Rizal, Antipolo, *Bur. Sci. 2194 Ramos,* March, 1907, growing in open wet places.

A species allied to *Oryza ridleyi* Hook. f., of the Malayan Peninsula and Borneo, differing from that species in its smaller spikelets, *fide* Hackel in lit.

The seeds of this species were sown in a nursery seedbed at the Alabang stock farm in June of that year, and it was given the same treatment and care as was accorded to other lowland rices.

At the end of the year there was no sign of flowering. The remarkable feature was its apparent resistance to drought, for the plot in which it was planted was repeatedly drained and the soil permitted to partly dry out yet there was little indication that this unusual treatment was seriously affecting the plants.



Philippine wild rice, *Oriza manilensis.*

Another lot of seed was planted this season and the plants are being carefully observed to note if the species possesses any truly valuable traits which would make it useful in hybridization.

The kernel of this species is very small and flat, in fact the smallest of any which has been seen by the writer. The kernel also has a red cuticle.

Agricultural Inspector Silverio Apostol reports upon it as follows:

> The kernel does not develop well, being relatively small in comparison with the size of the glume. The germinating power of the seed is low and quite easily lost. When sown the seed germinates very slowly, sometimes as much as ten days elapsing before there is any sign of growth.
>
> Growth is slow throughout but tillering is profuse, begining very early and continuing unusually late. New tillers were observed when some of the heads were exserted. The plants have a height of from 50 to 75 centimeters, measuring only to the base of the central panicles, but the culms vary widely in length.
>
> The panicles appear at irregular intervals, so there is no uniformity in ripening. The heading-out period lasted fully a month so it is anticipated that the maturing period will be equally long.
>
> As the seeds on the panicles ripen they drop off upon the ground. When not transplanted ripe seeds were gathered 85 days after sowing.

SOME OBSERVATIONS ON CHINESE RICE CULTURE.

By H. O. Jacobson, *Chief, Plant Industry Division.*

A popular conception of Chinese agriculture is that it consists mainly of rice production. Yet the thirty-second parallel bisects China in such a manner that more than two-fifths of the area lies north of this line and in this portion but a negligible amount of rice is produced.

It is a sufficiently accurate statement to say that the thirty-second parallel marks the northern boundary of the rice country. If, in addition, Manchuria, Mongolia and Tibet are included as a part of China, which, as a matter of fact, is usually the impression that most people have, the rice territory of China dwindles to small proportions relatively speaking.

It is a common thing to read some paragrapher's statement that the rice-eating population of China is this or that number of hundreds of millions, but the truth of the matter is that the millions of Chinese who do not eat rice as a staple article of diet would make a startlingly large aggregate. It would be a splendid thing if the world could or would realize that China is a country of great magnitude; perhaps it should be added that some of the country's features are enormous.

Certain industries in China are of great antiquity, among which the rice-growing industry figures very prominently. It would be very easy at this point to start a controversy about the early history of the rice plant and the development of its culture, but this question is of little importance unless it may point the way to the discovery of wild species of rice which may be useful in producing new and superior varieties for modern culture.

The writer recently enjoyed the opportunity of making a few first-hand observations on rice culture in China, as it is practiced in the southern part of the Province of Kiangsu, and in the delta of the West River in Kwangtung Province. Judging by information gathered from sundry sources, these districts are representative.

The first distinct impression one receives is that no attempt whatever is made to cultivate rice on soil which is not particularly suitable for it. The habit of carefulness in adaptations of crops to soil and climate is not so marked with other crops, although it obtains to a high degree except in the culture of maize.

The rice fields are found only in the low, level districts, which are located in the river valleys and deltas. No littoral regions were visited. These soils are sedimentary, of fine texture and high initial fertility. Examples of sedimentation are apparent in every big river.

Given a soil of large proportions of silt and clay a prime requisite is had for rice culture. Lying contiguous to large streams of fresh water the problem of irrigation is more easily solved and it has been solved in these regions. The canals and creeks intersect this area so completely that practically all the land planted with rice is easily irrigated.

The value of a soil for agricultural purposes depends upon the original material from which it has been derived and the state of fineness to which it has been reduced; in addition, for rice culture, there must be added the availability of ample amounts of water for irrigation. These conditions are found to a highly satisfactory degree in the district visited.

It is evident that these areas have been cultivated for a long period, and the question of maintaining soil fertility is certainly interesting. It is hardly probable that there is much organic matter in these soils, the physical appearance indicating the contrary. This should be a splendid field for those who have in recent years been in controversy regarding the ethics of fertilizing, to gather evidence to support their several divers theories.

One very apparent condition regarding which anything is seldom said, is that the huge areas of uncultivated lands and the waterways and lagoons contribute directly or indirectly to the maintenance of the fertility of the cultivated lands. Thus the herbage from the hills and the aquatic plants from the waterways and lagoons pass directly into the soil of the rice paddies as green manure or compost. The waste from the fish and the manure from the animals fed with forage produced on the uplands, also passes into the cultivated soils. When the high ratio of human population to animal population is considered, it is easier to understand how and why the use of night soil for fertilizer has become so common a practice. The importance of animal manure is relatively slight in comparison.

We have heard much about the value of night soil as a fertilizer, but judging by the yields obtained, and the general appear-

ance of the crops viewed, it is the opinion of the writer that eventually it will be discovered that the practice must be amended to include the addition of certain elements in the form of chemical or artificial fertilizers to make maximum production possible.

To one who is accustomed to the large number of varieties of rice which abound in the Tropics, the small number found as the northern limits of the rice region is approached is a feature that is appreciated. One of the greatest contributing factors to low yields and wastes in milling is the multiplicity of varieties which obtains in the tropical rice area. The number of varieties of rice grown in the district visited is much larger than it should be.

The appearance of the fields indicated that the soil had been very thoroughly prepared, and at harvest time the absence of weeds of all sorts was remarkable.

Irrigation is continued much later than is ordinarily considered essential. In many cases water was being applied when the harvest was due within two weeks. There appeared to be but one way of raising the water from the canal, creek or lagoon, and that was by means of an endless wooden chain running in a trough, operated by a treadmill, or, in other instances, by a bullock or water buffalo, hitched to a big bull-wheel directly connected to the shaft in the upper end of the trough. This type of apparatus for raising water is almost identical with devices seen in Japan and in the Philippines. As a rule, the water is raised but a short distance, rarely exceeding four feet.

The spacing of hills in the fields was uniform and seldom exceeded 20 centimeters between hills. In some fields the spacing was closer but the figure mentioned appeared to be the average distance. The number of bearing culms per hill was also quite uniform, the number most commonly appearing being nine, ten and eleven. As nearly as could be ascertained, the number of seedlings set in the hill would range between three and five. There were very few missing hills and but very little evidence of resetting. The number of grains per panicle very frequently was found to be less than a hundred, but panicles were also found which exceeded that number. The kernel type most prevalent was short, broad and thick, white and non-glutinous. This type is very different from the one represented by Saigon rice appearing in the Manila market.

There were a number of awned varieties and with regard to color of hull, as great a range from pale straw color to black as could be desired.

In the Philippines, lowland rice rarely is less than 100 centimeters in height. The prevailing short straw in the district visited was very noticeable in contrast, since many large areas covered with apparently normal plants had not a hill in which the culms were a meter long.

The writer was informed that the season's crop was the best produced in five years, and if that was the case, the general characteristics observed should be approximately normally developed.

The rice harvest begins in the north and proceeds southward by easy degrees, which is in direct contrast with the wheat harvest in North America, which begins in the south and proceeds northward.

The usual implement used in harvesting is a small sickle with a blade of 15 centimeters in length, attached at right angles to a wooden handle about 20 centimeters long. The harvester cuts a hill at a time, and, if the soil in the field is sufficiently dry, lays it flat on the ground. The usual practice is to cut several rows of hills at the same time, cutting the straw very close to the ground except the one outside row. The outside row is cut about 10 centimeters above the surface of the soil and the handful of rice plants from each hill is laid crosswise of the rows so that the panicles rest on the outside row of stubble. When the field is cut it presents a neat display of windrows, the heads all on one side, slightly raised, and the straw lying neatly and evenly. The crop is allowed to lie until it dries sufficiently so it may be threshed. At that time of the year there is little likelihood of rainfall, so the practice is quite safe.

Certain sections of this district are subject to frequent overflows and then the harvest method is slightly changed. Instead of putting the handfuls on the ground, small sheaves are loosely bound and these suspended on wooden tripods which are set up in the field as the harvesters proceed.

In the Philippines we find it possible to plant a much larger area with a given number of laborers than can be harvested, and, for this reason, many rice farmers select an early, a medium and a late maturing variety for their fields. This practice is also found in China. The rice farmer who has land subject to overflow, plants different varieties so the harvest will be extended over a sufficiently long period that he may handle it with a minimum supply of equipment and with his own labor. It is nothing uncommon to see three or more varieties growing side by side in a field of one-tenth of a hectare.

The unit of land measurement is the *mow* which is equivalent to one-sixth of an acre. To be exact, the legal mow contains 7,260 square feet, but among the Chinese a mow containing but 6,600 square feet is sometimes found, and it may be imagined that the latter size is the one used when yields are computed or land is being sold.

Just as soon as the panicles are sufficiently dry so that the grains will shatter easily threshing begins. There are three principal methods. In one case a large heavy wooden box, widely flaring and mounted on runners is taken to the field and moved from place to place as required. This box can accomodate four threshers. A large handful of the grain is grasped near the butts of the straw and the grain is removed by beating the panicles against the inside surface of the flaring box. The grain falls down towards the center of this box from which it is removed and carried to the farmer's house in sacks or baskets. When another method is employed the loose grain is made up into large bundles and carried to the farmer's house either on the man's own back, or packed on donkeys, bullocks or carabao, or carried by boat, or wheel-barrow. The threshing floor, which is a convenient term, but misapplied in this case, is located close to the farmer's house. Sometimes the flaring box is used but usually a small slanting table on four legs, the surface of the table consisting of wooden slats, is employed. Only one operator can work at each table and he removes the grain by beating the heads against the surface of the slatted table. The grain falls through into a box or basket, or on a mat or the earth as the case may be. Where the amount of grain to be handled is considerable, a threshing floor is made either of baked clay or of stones. The loose grain is strewed about on the floor and a large, tapering corrugated stone roller is drawn about over this material. The roller may be drawn by a water-buffalo, bullock, or by men and women. Occasionally, the roller is smooth and not tapering, but the advantage of using the tapering, corrugated roller is quite obvious. It tends to travel in a circle of a given radius for one thing. Sometimes the animal hitched to this roller is encouraged to move by ingenious means. A common scheme is to suspend a bundle of nice succulent grass barely beyond the animals head and in his futile attempts to acquire this tidbit he proceeds to move around the threshing floor in a highly satisfactory manner. Another scheme is to tie a bundle of grass on one side of the animal's head so that in trying to eat the grass he tends also to move towards the center of the floor and travel in

a circle. After the grain is threshed it is spread out on mats in the open to be sundried sufficiently to prevent heating in storage.

A most unusual crop is sometimes gathered immediately after the rice is taken off. This crop consists of bricks. Where the soil is of the proper texture, the rice stubble is shaved off even with the surface of the soil and a knife is run through the soil lengthwise of the plot, cutting the soil into narow strips of uniform widths. These strips are cut into sections and a trench dug next to the first strip. The knife is then run along underneath and the bricks carefully removed one by one and neatly laid out in the sun to dry. When the bricks are sufficiently dry to permit handling they are piled in ricks for further treatment. This is a case of making bricks without straw, but the numerous fine roots of the rice plant in the soil is a very good binder and serves the purpose admirably.

The feature of greatest interest is yield. Estimates on various fields were given, ranging from 160 to 300 catties per mow. A catty is equivalent to one and one-third pounds avoirdupois, varying slightly according to the three standard catties. These estimates are equivalent to 1,278 to 2,400 pounds per acre or 28.4 to 53.3 bushels of rough rice.

The above figures are regarded as conventional, since in the writer's opinion the yields had a wider range. Many fields did not yield as much as the indicated minimum, and several fields gave every indication of producing considerably more than the maximum. Here, as in all communities, was evidence of difference in the skill and application of methods, according to the individuals. There is not much variation in the methods employed but a great difference in the thoroughness in the application of methods. It was clearly evident that, in one case, we saw the results produced by a good farmer, in another, those of an indifferent one, and again, the pitiful results produced by the inferior farmer.

In places was noted splendid uniformity of seed, in others the fields showed mixtures of varieties hopelessly inferior.

In the south, notably in the vicinity of Canton, the spacing of hills is more open, the distance often being as much as 40 centimeters but more seedlings are placed in the hill.

An easy method of irrigating was noted in this district. The lands bordering on the river are apparently more recently formed. At any rate, they lie below the level of the river at high tide. Consequently, when the high tide raises the river water level, the water overflows these rice lands and remains several hours, but

as the tide ebbs the water flows off again. This is the least expensive irrigation scheme on record.

In general the rice industry, at least in the regions visited, appears to be standardized to a considerable extent. Through centuries of experience it has been determined that certain lands are most suitable, certain practices reliable and given methods most productive, hence there is but slight variation when one district is compared with another.

It appears that the need is for more rice to feed the people, and this need cannot be met by any revolutionary changes in the industry. The way out lies in the elimination of poor varieties now in culture and the evolution of more productive varieties to be grown instead. That there is a great opportunity along these lines no one who is at all familiar with modern agricultural science doubts.

RICE CULTURE IN CALIFORNIA.

By H. O. JACOBSON, *Chief, Plant Industry Division.*

We have read with interest Farmer's Bulletin No. 688 "The Culture of Rice in California," published by the United States Department of Agriculture, which has just come to hand.

It is stated that the Office of Cereal Investigations inaugurated variety tests of rices in the vicinity of Biggs, California, in the spring of 1909, which were continued in 1910 and 1911.

In 1912 the Biggs Rice Field Station of about 23 hectares was established through coöperation with the Sacramento Valley Grain Association, an organization composed of ranchers.

The first commercial rice crop in California was grown in 1912, consisting of about 570 hectares. This crop was profitable and in 1913 the area was increased to 2,430 hectares, which produced an average yield of approximately 86 cavanes rough rice per hectare. In 1914, 6,478 hectares were planted which yielded to the growers an average cash return of ₱247 per hectare. Yields have varied, of course but in instances as much as 180 cavanes per hectare have been harvested.

The leading varieties are such as require six months to reach maturity and there is an eager desire for earlier sorts.

This bulletin contains much sensible advice and the summary is herewith quoted with a few omissions of matter not pertinent to our conditions.

Clay soil with an impervious subsoil, if it lies in level tracts and can be well drained, is well adapted to rice.

Shallow soils are preferable to deep soils, because less water will be required to submerge them.

Rice requires an abundant and always available supply of water.

On typical adobe, and probably on all of the clay soils on which rice may be grown, it may be necessary to apply water to germinate the seed. Great care should be taken in irrigating to obtain germination. Before the plants emerge, water should not be allowed to remain on the land longer than 24 to 48 hours after each irrigation. After planting, the soil should never be allowed to dry out. The water should be applied not less than 4 inches deep, and preferably from 5 to 6 inches, and should be applied approximately 30 days after emergence.

The field should be rapidly drained when the heads are well turned down.

The growing of rice on soil that is simply kept moist and not submerged is not to be seriously considered.

More data must be obtained before definite statements can be made regarding the quantity of water that may be necessary to produce a crop of rice under California conditions.

Field and outside levees should be permanent and accurately located.

Poor drainage, or the lack of drainage, results in underproduction through the waterlogging of the land and the accumulation in the surface soil of harmful salts, commonly called alkali.

Rice should be cut promptly when ripe. If exposed too long to the sun the ripe grains are likely to become cracked, which will cause heavy breakage in milling.

Early-maturing varieties of good quality that will produce high yields are needed to protect the crop from the probable losses through high humidity and rain, which increase as the harvest period is delayed.

Barnyard grass is the worst weed to be found in the rice fields of California. It has taken possession of more than 2,000 acres of rice land in the Sacramento Valley and is now present in alarming quantities on a considerable acreage, which will soon be rendered unprofitable for rice growing unless active steps are taken for its complete eradication or control. Seed rice containing the seed of barnyard grass should not be used. When present in a field in small quantity it should be removed by hand. A rotation of crops, including a cultivated one, and summer fallowing may be employed as the best means of obtaining the complete eradication of this weed.

CURRENT NOTES—FOURTH QUARTER.

NOTES BY H. O. JACOBSON, Chief, Plant Industry Division.

CORN CONSUMPTION.

At the Fiftieth Congress of the American Chemical Society held at New Orleans, March 31 to April 3, 1915, E. T. Berford, president of the Corn Products Refining Company, submitted a communication giving some very interesting information regarding the disposition of a huge amount of corn (maize).

It is stated that 50 million bushels of corn are now annually consumed in the industries and converted into the following products:

	Millions of pounds.
Corn sirup	800
Starch	600
Corn sugar	230
Gluten feed	625
Oil	75
Feeding cakes	90

There are additional minor sub-products. According to the report contained in the Monthly Bulletin of Agricultural Intelligence and Plant Diseases (Rome) the progress in the mode of preparation enables the corn (maize) products to compete with those of wheat, sago, rice, etc., the products of which are limited to starch, and liquid and solid glucose.

The Philippine corn crop of last year amounted to 366,570 metric tons of shelled corn and for the first time in recent years the prices were sufficiently low so that corn could have been purchased here for sale in foreign markets.

For the present, there is no outlet for any surplus corn, but if the industry is to progress and attain the proportions it is easily capable of, some means must be provided for quick and easy disposition of such portion of the crop as is not needed for human food or for the feeding of animals.

It is highly improbable that the United States will permit the entry of Philippine corn, due to the presence here of the fungus disease commonly spoken of as corn blight, therefore it will be necessary to turn to the European markets, which have already accepted corn from blight-affected regions.

Finding an export market for our surplus corn is a business proposition, which can undoubtedly be easily managed. Problems which will arise in connection with the preparation of the product for export have already been solved elsewhere and this information can be readily secured.

The growing consumption of corn in the industries is encouraging news for regions such as the Philippines, which have great potential capacity to produce this crop.

RICE INVESTIGATIONS.

The literature of tropical agriculture is filled with material on the subject of rubber, sugarcane, coconuts and cacao, and minor crops have had considerable attention, but the most important crop of all—rice—has only very recently been given serious attention.

Today, we find systematic investigational work with rice being done in Italy, Japan, India, Indo-China, Java, British Guiana, Ceylon, United States of America, and elsewhere, the countries of the subtropics or sub-temperate regions being first in the field while the countries in the Tropics have entered later.

It is perhaps unfortunate that the rice industry has been neglected so long, but, the work that has been done on barley, wheat and oats has a broad but useful application to the problems in the improvement of rice and can be and is being adapted thereto.

RICE EFFICIENCY STANDARD.

Percy A. Hill, a practical rice grower in the Province of Nueva Ecija, P. I., employs an efficiency standard by which he judges the men he employs. After taking into consideration the quality of the soil, the water supply and weather conditions, it is believed to be more of a personal or man-factor that makes the differences in yield, than is commonly supposed and this assumption is borne out by the records kept and appears to be correct.

In his region the standard is set at 200 cavanes or 8,600 kilos per man and it is surprising how closely this standard is approximated or even exceeded year by year. The hectare yield is estimated at 84 cavanes or 3,612 kilos rough rice, which is practically four times the average yield per hectare for the entire rice area of the Philipines.

This brings up the economic question of the relative importance and significance of return per unit of area cultivated compared with the return per man employed. This topic has

been freely discussed by the corn (maize) growers of the United States, also by the growers of small grains, and has resolved itself into approximately the following: Where land is suitable and abundant and labor scarce the per-man-yield is most important but where the opposite conditions prevail the per-unit-of-area-yield comes first. With lowland rice, due to the expense involved in diking and supplying irrigation water the per-unit-of-area-yield will require first consideration, even though there is much raw land available at low initial cost.

NUMBER OF SEEDLINGS AND SPACING OF HILLS IN RICE CULTURE.

In the Annual Report of the Agricultural Stations of Bihar and Orissa (1913–14) N. S. McGowan submits the following conclusions regarding the number of seedlings to be set in the hill and the spacing of hills.

Spacing hills about 40 centimeters apart seemed preferable to spacing at 15, 22.5 or 30 centimeters. Four seedlings per hill gave the largest yield generally, but with very heavy applications of animal manure one seedling per hill equalled or exceeded the others in yield. Other hills contained 2, 4 and 6 seedlings each.

NUMBER OF TILLERS AS AFFECTING THE WEIGHT OF GRAINS IN RICE.

E. Thompstone, in the Agricultural Journal of India, in an article entitled "Some Observations on Upper Burma paddy (grown under irrigation)," states that as the tillers increase there is an increase in the weight of grain but this increase is not in proportion to the number of tillers produced by the plant. He also reports that as the number of tillers increase in number the average yield per tiller decreases.